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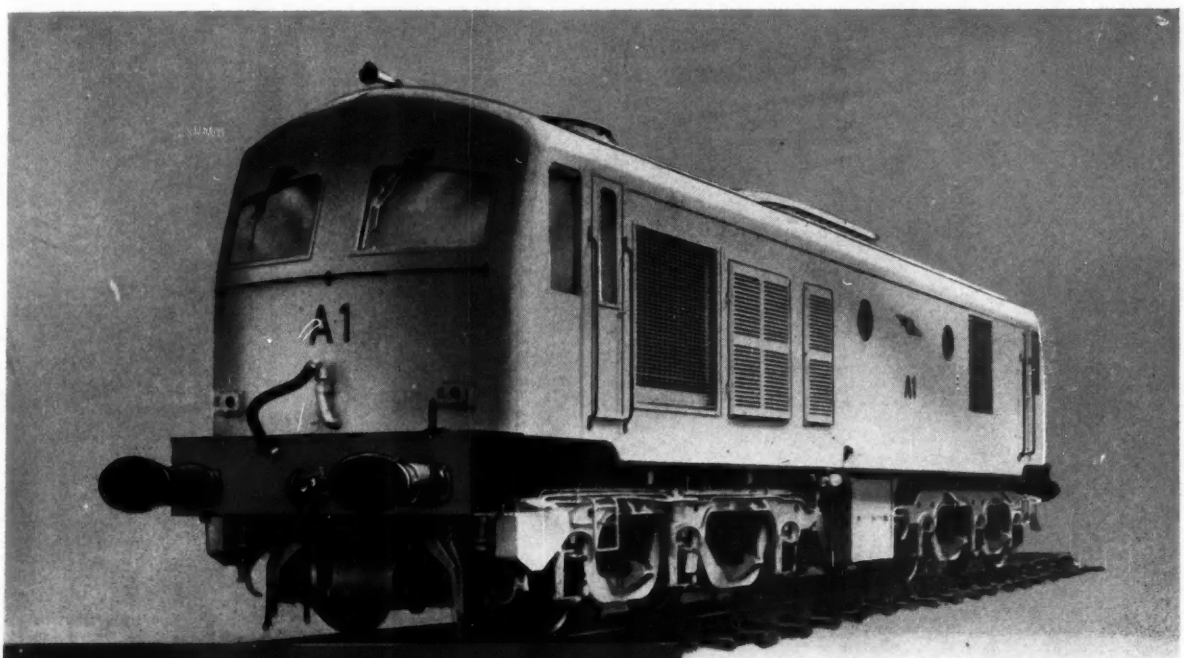

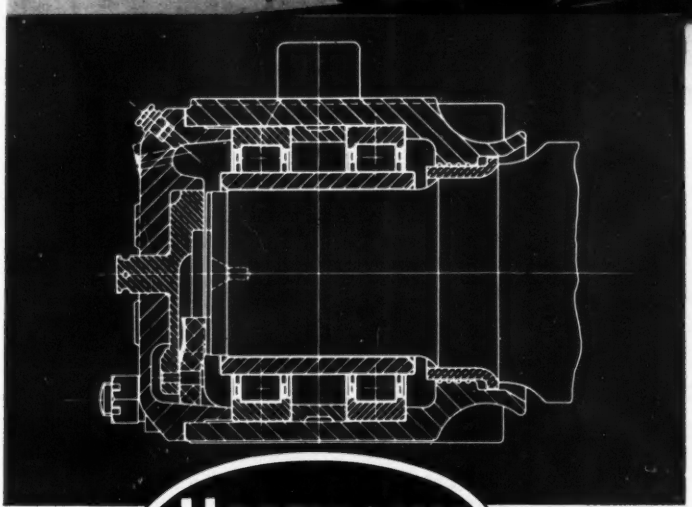

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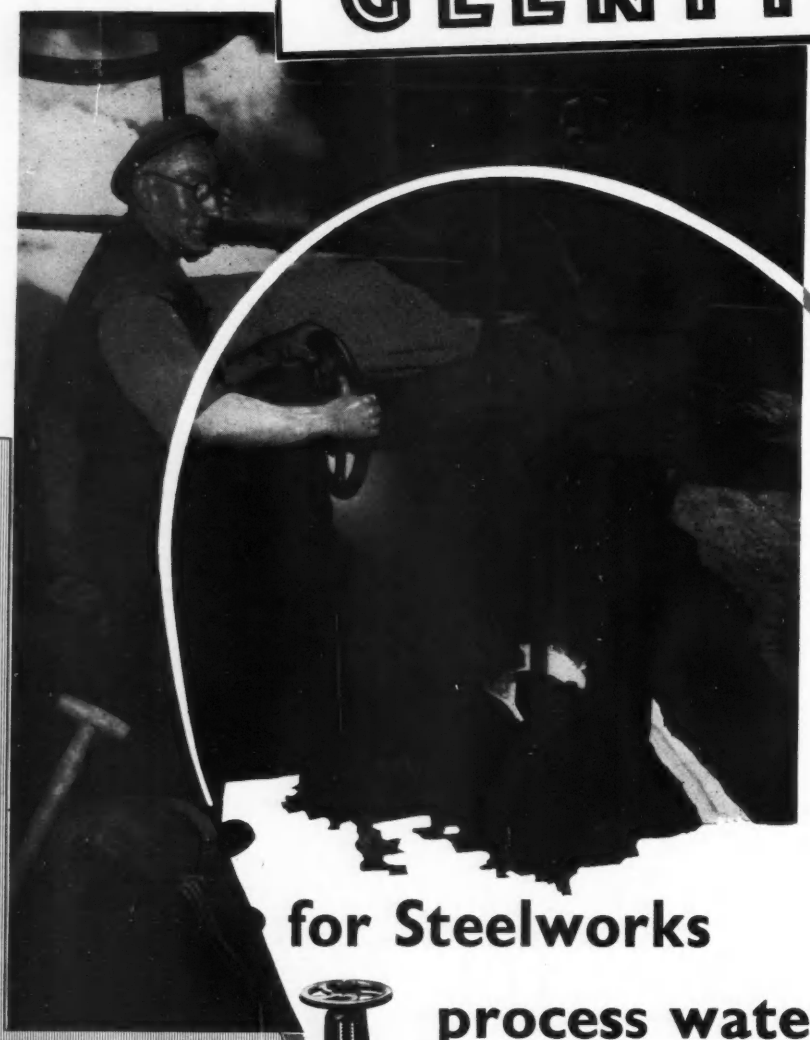

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THE ENGINEER

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CONTENTS

LEADING ARTICLES—
London Omnibus Centenary 109
Kariba Dam 110
Cromwell Road Report... 110

ARTICLES—
Air Registration Board 113
Aswan High Dam 112
Automobile Transmission Factory. (Illus.) 133
Carrington Power Station. (Illus.) ... 124
Cationic and Nonionic Chemical Plant. (Illus.) 131
Dingle Bank Boiler Installation 132
Engravings of 1873... 119
F.B.I. Overseas Scholarships... 113
Fuel Research 112
Measurement of Cutting-Tool Performance with Radioactive Isotopes. (Illus.) 127
Mechanical Engineering Research Report for 1955 112
Modern Dewatering Methods in Irrigation Problems. No. I. (Illus.)... 114
Pumping Plant for the Wallasey Impounding Station at Mersey Docks. (Illus.) 129
Report of the U.K. Atomic Energy Authority 113
Rocket Power Plants. (Illus.) 117
Snap-Action Limit Switches. (Illus.)... 133
Some Recent Industrial Structures. (Illus.) 128
Volta River Project... 112
100 Years Ago... 112
120MW Reheat Sets in C.E.A. Power Stations 113

METALLURGICAL TOPICS—
Hydrogen in Steel 120
Bessemer Centenary 120
Sulphur Embrittlement of Cobalt... ... 120
Surface Blisters on Steel... 121
Surface Effects in Fatigue 121

CONTINENTAL SECTION—
Association Technique Maritime et Aeronautique. (Illus.) 136

AMERICAN SECTION—
Industrial Nuclear Facilities Works in Virginia. No. I. (Illus.) 139
First Enrico Fermi Award Conferred on Dr. John van Neumann... 141

LETTERS AND LITERATURE 122

LETTER TO THE EDITOR—
Oil Test Laboratory 122

LITERATURE 122

OBITUARY—
Sir Henry Lewis Guy 111

NEWS AND NOTES—
African Engineering Notes 134
British Patent Specifications. (Illus.)... 143
British Standards Institution... 144
Catalogues 144
Forthcoming Engagements 144
Industrial and Labour Notes... 135
Launches and Trial Trips 144
Personal and Business 142
Technical Reports 131

LONDON OMNIBUS CENTENARY

The commemoration of centenaries is a worthy custom and, among other things, it enables us not only to establish reliable data on past progress, but to gather inspiration for new efforts. In the exhibits staged last week at Charing Cross Underground Station, the London Transport Executive depicted some salient phases in the history of public road transport in Greater London, commencing with the introduction (on January 7, 1856) of the first omnibuses of the London General Omnibus Company. In 1856, the population of Greater London was estimated at 2,900,000, and there were in service 450 horse-drawn omnibuses. By 1939, the population had increased to 8,700,000 and the number of buses (now all motor driven) to 4500. The history of the omnibus did not commence, however, with the London General Omnibus Company, since as long ago as 1662 an omnibus service was introduced in Paris, the first route (opened on March 18th of that year) connecting the Porte Saint-Antoine with the Luxembourg. No transport undertaking ever had so illustrious a promoter, since the idea of carrying passengers at low fares from one part of Paris to another originated with Blaise Pascal. With his intimate friend the Duc de Roannez, Pascal formed a company to finance the venture, it being his intention that any profits which might accrue would be applied to the relief of the poor of Blois. An account of the opening ceremony on March 18, 1662, is extant in a letter written by Pascal's sister and we are told by Jean Mesnard (*Pascal : His Life and Works*) that in Paris the vehicles maintaining the services were referred to as " carriages at five sol fares."

In London, the first omnibuses appear to have been introduced during 1829, a Mr. Shillibeer starting—with two vehicles—a service from the Bank to the " Yorkshire Stingo " in New Road. This was on July 4, 1829, and we read that each bus carried twenty-two passengers inside, only the driver riding outside. The fare was 1s. for the whole distance. The mechanically propelled omnibus was first put on to the streets of London by Walter Hancock, of Stratford, Essex, who, on April 22, 1833, commenced running a steam-driven omnibus, the undertaking being known as the London and Paddington Steam Carriage Company. The vehicle speeds are reported to have ranged from 16 to 20 miles per hour, and while Hancock was certainly not the first to introduce a self-propelled road vehicle, he has been regarded as the pioneer, in a practical sense, of the mechanically propelled omnibus. When, twenty-three years after the formation of the London and Paddington Steam Carriage Company, there came into existence the London General Omnibus Company, the two-horse bus was the unit employed, and it remained in use by the L.G.O.C. until 1911, when the " B " type four-cylinder petrol engined bus was in service. It is significant of the road transport problems awaiting solution that after watching a procession of buses (including some horse-drawn buses) the chairman of the London Transport Executive is reported as having remarked that the latest 130 h.p. diesel-engined bus, with power-operated brakes and private car acceleration, " is only a few miles an hour faster from end-to-end of its routes and barely faster at all in the centre of London, than the horse-buses which disappeared in 1911." This exasperating immobility, world-wide in its incidence (*Omnibus hoc vitium est !*), is not confined to motor buses, and we recall the thought-provoking notice which is (or recently was) displayed in Toronto subway cars. It reads as follows :—" A highway twenty lanes wide would be required to carry in automobiles the number of people now being served by Toronto's Subway."

A feature of the subway in Toronto is the streamlining of the subway (electric train) traffic with the surface (omnibus) traffic. The fact that this 4½-mile long subway—opened during 1954—carried 73,000,000 passengers in the first twelve months of its operation enables one to grasp the contribution which it must be making towards lessening the congestion of surface traffic. While the exhibition at Charing Cross relates to equipment intended chiefly for city routes, there is an ever-widening scope for the development of inter-city road transport involving comparatively long journeys. One has only to travel by such services as the

"Scenicruiser Express" between New York and Toronto to realise the degree of road travel comfort now rendered possible by an air-conditioned omnibus provided with complete toilet facilities, ample accommodation for luggage and cushioned on air-suspension springs. In the United States and Canada these amenities are not inaptly described as "travel treats." The travel treat likely to be most appreciated by London bus users would be a lessening of the congestion which, as the chairman of the London Transport Executive remarked, is such as to render the speed of traffic in the centre of London barely faster than it was with the two-horse bus of nearly half-a-century ago.

KARIBA DAM

The hydro-electric project at Kariba gorge on the Zambesi River has been surrounded by controversy since it was first seriously considered. The award of the main contracts stirred up some further contentious talk, but it can be hoped that now serious constructional work has been started, the discord will gradually die away. Indeed, if there is to be controversy over a scheme of this kind, the correct time for it is before construction starts.

The first great issue, and one which has been enthusiastically championed, one way or the other, by local opinion, hinged on the relative merits of the Kariba and Kafue schemes. The decision was made a few years ago to build the Kafue scheme first; although smaller and not yielding enough power on its own to meet the estimated demand in the 1960s, it promised an earlier date for first power generation. Work was actually started on the Kafue scheme. But the decision was reversed, and in March, 1955, Sir Godfrey Huggins, Prime Minister of the Federation of Rhodesia and Nyasaland (federation was part of the background which made the controversy more intense) announced that the Kariba scheme would be built. The original course was based on a report made by Sir William Halcrow, Mr. H. J. F. Gourley, Mr. C. H. Pickworth and Mr. Geoffrey Kennedy. Later, however, it was thought that a further, independent survey of the two schemes was needed, and Monsieur Coyne was called in. The Kariba scheme as it is now to be built has two French firms and one British firm of consultants, jointly responsible for the civil engineering, and a British firm of electrical and mechanical consultants. We are preparing a detailed account of the scheme for our next issue; for the present it may be pointed out that the first power (less than 200MW) is expected early in 1960. The dam will be about 400ft in height, with an underground power station close by it. The ultimate capacity of the scheme, when a second power station is built, will be 1200MW, and it will have a firm annual energy output of 8145×10^6kWh.

The controversy of Kariba against Kafue has not aroused much interest in this country. The main concern here has been over the somewhat restricted part of the scheme which is the responsibility of British engineers. Division of the consultants' duties between two British and two French firms has not aroused much, if any, comment, but the award of the main contract for the dam to an Italian consortium has been criticised. It has been suggested that the Italian firms had a government subsidy, and their employees would accept lower standards than British contractors' employees. In fairness, however, it should be pointed out that Italian contracting firms have shown very commendable skill in carrying out hydro-electric schemes in their own country, where, presumably, competition is keen, and where several dams comparable with the Kariba dam have been built very economically. Obviously, the reason for seeking world tenders is to obtain the lowest bid; but it is, nevertheless, disappointing to see British contractors outpriced, and also to see such a large part of the consulting work in foreign hands. The main contracts for the power station plant have, however, been gained by British firms, who deserve congratulations.

CROMWELL ROAD REPORT

The British Road Federation is to be commended for the investigation it commissioned into the traffic capacity of the proposed road junctions at the eastern end of the Cromwell Road extension scheme, which the London County Council has under construction. The scheme, as a whole, is only partly an L.C.C. responsibility; it has been described as the first major road project in London for fifty years, and it will cost nearly £4,000,000. The report called for by the Federation was published recently, and was summarised in our issue of July 13th. Briefly, the situation is this. A large roundabout system is proposed at the Hammersmith end of the road, with a "flyover" carrying one of the main traffic streams over it. The L.C.C. does not propose to build the "flyover" road at present. The report, which is signed by Mr. C. P. Andren and Mr. N. V. E. Seymer, is based on traffic surveys of the area, and states flatly that the roundabout system is insufficient, even for present-day traffic, and will be only just adequate with the "flyover" road as well. The L.C.C. has made no statement about the report. But since the "flyover" road can be built after the rest of the scheme is complete, presumably the Council's engineers feel that experience of actual traffic conditions at the roundabout might well be acquired before a decision is taken to construct the "flyover" road.

And so there would appear to be no great cause for controversy, either way. But, in fact the report goes further, by implication, than that brief statement of the situation suggests, for it challenges the basic approach to the design of new roads in London, adopted by the various authorities concerned, and in this case in particular, by the L.C.C. Some points of detail may be taken by way of example. Technical opinion has been urging that new road schemes, and in particular motorway routes, should be based on extensive traffic studies—on "origin and destination" surveys. The report springs from such work, carried out, as far as can be judged, more systematically and in greater detail than was done by the designers of the road. Considerable space is given in the report to establishing a definition of the practicable number of vehicles which can use a roundabout. That is evidently a somewhat contentious topic, and it would appear that the roundabout is regarded with disfavour by many authorities unless the traffic is limited. Even so, roundabouts for gigantic traffic streams of 2000 and 3000 vehicles per hour seem to be characteristic of the L.C.C.'s recent designs. Apart from the Hammersmith one, a roundabout system is proposed for the Elephant and Castle; that, too, has been criticised! The remarks on pedestrian traffic at the Hammersmith roundabout also have particular force. Accidents are considered likely with such a configuration, particularly since school children will use the crossings regularly. Hence light-controlled crossings are suggested—"the use of signals of any kind would, of course, be a negation of the principle of continuous flow; but it is clear that continuous flow will not in any case be achieved."

It should perhaps be explained that overall policy towards road construction is determined, in the first place, by the Ministry of Transport and Civil Aviation, and local authorities must follow the Ministry's wishes, if they are to qualify for grants. The resulting attitude seems to be that a relatively minor improvement here and there will ensure that "things won't be too bad." It is our opinion that some such controversy as this one will arise at the ends of every road scheme proposed in London, as long as such schemes are tackled piecemeal. A master plan for a network of metropolitan motor roads is essential as the basis of satisfactory road improvements. At present there is no such plan. Schemes such as the Cromwell Road extension, although, doubtless, they are beneficial, can therefore have only a severely limited value, judged by the general picture of traffic conditions in London. That conclusion emerges quite forcibly from a study of the Federation's report; it can be reinforced by taking a journey, by car, through London.

Obituary

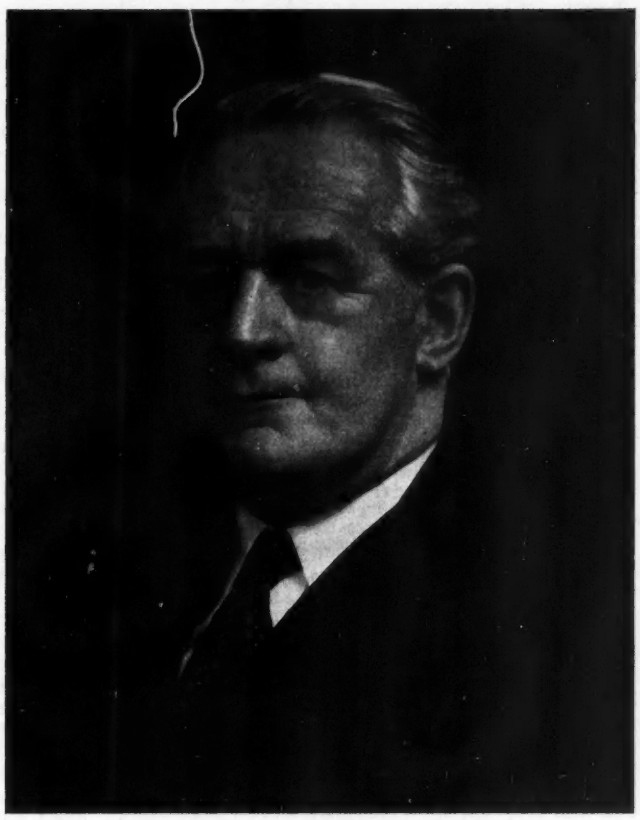
SIR HENRY LEWIS GUY

It is with deep regret that we have to record the death last Friday of Sir Henry Guy, C.B.E., D.Sc., F.R.S., who was Secretary of the Institution of Mechanical Engineers from 1941 to 1950. He was 69 years old.

The details of Sir Henry's life can be quickly touched upon. His first major contact with engineering seems to have been on the Taff Vale Railway, where he was a pupil under the late Mr. T. Hurry Riches. From 1907 to 1910 he studied at the University College of South Wales, proving himself academically brilliant by gaining College diplomas in both mechanical and electrical engineering simultaneously. Even at that early age he was clearly a glutton for work. Later he won the Bayliss prize of the Institution of Civil Engineers, a Royal Research Scholarship and a Whitworth Exhibition. In 1910 he joined the technical staff of the British Westinghouse Company, in 1915 he became its centrifugal pump and turbo-compressor engineer, and in 1918, so quick was his rise, he was chief engineer of that company's successor, the Metropolitan-Vickers Electrical Company, Ltd. Later he became a director of the Metropolitan-Vickers Electrical Export Company. In 1939, with war looming on the horizon, he was invited to join the advisory Council on Scientific Research and Development and later he became chairman of its Gun Design Committee and of its Static Detonation Committee (Bombs). He was also appointed chairman of the Committee on Armament Development, and he presided over other committees concerned with armament research and development and the technical organisation of the Forces. In 1944 he became a member of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research, and in 1945 he was appointed chairman of the D.S.I.R. Committee on the Essential Requirements for Research in Mechanical Engineering, which led to the setting up of the Mechanical Engineering Research Laboratory at East Kilbride. Sir Henry was created a knight in 1949.

But how little one can learn about a man from a mere recital of posts held and honours bestowed! The things that really count in our estimation of a man are far more personal. Many a man has risen to as high a position, served upon as many committees, and had greater honours bestowed upon him, and yet made far less mark upon his times than did Sir Henry. No man, it is said, is irreplaceable; and in the sense that others can always be found who can carry on a job the remark is true. But no man of character can ever do a job just as his predecessor did it. Sir Henry had so strongly marked a character that far from being moulded by the jobs he did he left his mark strongly upon them. So strong, indeed, was his character that it made him enemies as well as friends. For having used his fine brain to think out exhaustively an answer to every problem that was presented to him, he was impatient of criticism and angered by opposition. To work with him it was needful to be prepared to fight hard to justify rationally opinions that differed from his. But to follow, to accept his leadership was to receive swift and full encouragement and all the backing that he could give. Particularly was his support and encouragement always readily given to younger men.

The major change in Sir Henry's life came in 1941. He was then, as we have related, chief engineer of Metropolitan-Vickers and a director of its export company. He had also for three years been a Vice-President of the Institution of Mechanical Engineers. To all appearances quite suddenly, he gave up the prospect of becoming President and offered his services to the Council in the capacity of Secretary. What prompted him to do it? Surprised members of the Council, no doubt, asked themselves that question. But, being wise, they did not let the question unduly trouble them. The prime point was that an outstanding figure was offering to take on the job of Secretary just when, in the midst of war, it would have been hard indeed to find anyone at all of sufficient stature. That it meant to Sir Henry a heavy financial sacrifice—for he had necessarily to resign from his posts with Metropolitan-Vickers—was Sir Henry's affair, not theirs. The offer, whatever prompted it, was eagerly seized upon.



Sir Henry Guy, C.B.E., D.Sc., F.R.S.

Now, looking back upon the event, it is easier to have some glimmering of understanding of what was going on in Sir Henry's mind. As an up and coming junior in the Metropolitan-Vickers organisation, young Henry Guy had, no doubt, been happy enough. He had more to do with technicalities than policies. But upon reaching more exalted altitudes he became more aware how, in the 'tween-war days of depression and partial depression, questions of policy were having a bearing upon technical developments. The situation irked him. As Secretary of an Institution he would have a freer hand. Moreover, it is by no means impossible that he already foresaw that he had a major part to play in winning the war. For he could hardly have served with such great distinction on the many committees which we have mentioned had he not been independent of commercial attachments. Furthermore, he had for years held the fortunes of the Institution close to his heart and he probably foresaw, not only that the character of the Institution was changing, but that the change ought to be encouraged, that it must become after the war a great national Institution rather than the more intimate society it had once been if it was to continue to serve its purposes. Certainly during his Secretaryship Sir Henry greatly raised the prestige of the Institution. There can be traced to his influence the creation of that machinery by which the three major engineering institutions of this country now consult together, instead of aloofly going their separate ways; and he had much to do with the setting up of those conferences by which the major British institutions are linked with similar bodies abroad. It was no doubt upon the ground of increasing the prestige and national and international influence of the Institution that he based his support and enthusiasm for the amalgamation with the Institution of Automobile Engineers. It is, indeed, probable that he would have liked to have gone further and to have drawn into the Institution as "Groups" or "Sections" certain other societies within the mechanical engineering field which he may have felt should never have been allowed to have a separate existence, thus creating a great Institution, the sole representative of mechanical engineering in Britain.

But his life ended in sadness. The closing years of his Secretaryship were marred by the storm of criticism aroused amongst a considerable minority of the members of the Institution about the amalgamation. Any thought of further amalgamations, if Sir Henry had ever held them, were now clearly out of the question; worse, much of the animosity aroused was directed at the personality of Sir Henry himself; and worse still, Sir Henry's health was failing. He had always been a glutton for work; but he had driven himself too hard during the war. In failing health he was in no fit state in the post-war years to meet with equanimity the criticisms and the pin-pricks of those who opposed the amalgamation. He took it all much too much to heart and his health further suffered. Resignation at last became inevitable.

His friends—and, though his enemies made the greater noise, he had very many of them—hoped that relieved of cares and anxieties, he would recover health. But—alas!—it was not to be. Slowly health continued to ebb away. A great man died last Friday.

A Seven Day Journal

Volta River Project

THE report has been published of the Volta River Preparatory Commission, which was set up by the Governments of the United Kingdom and the Gold Coast. The Volta River project is a scheme for hydro-electric development and aluminium production in the Gold Coast. It envisages a dam across the Volta River, a power station of 600,000kW capacity, and a smelter using most of the power generated for the production of aluminium from the large bauxite deposits in the Gold Coast. The commission reports that, subject to certain reservations, the scheme is technically sound, it could be constructed successfully and operated competitively, and could not be significantly improved from an economic point of view; whilst it would bring its greatest return if maximum production were achieved as soon as possible. The primary objective of the scheme is the production of some 210,000 tons of aluminium a year and the project would take the form of a partnership between the Governments of the Gold Coast and the United Kingdom, Aluminium, Ltd., of Canada, and the British Aluminium Company, Ltd. Based upon prices ruling in September, 1955, it is now estimated that the initial stage of the project to produce 80,000 tons of aluminium a year would cost about £160 million, and £230 million by the final stage, when production would be 210,000 tons a year. Part of the increase in these costs as compared with the original estimates of £100 million and £144 million, respectively, arise from the proposal to build a higher dam, and increases in the prices of materials. The commission's investigations showed that more power could be obtained from the project than was thought possible in the earlier inquiries, by the construction of the higher dam to take advantage of an extra 10 per cent of power from the river at Ajena. A further 65,000kW of continuous power could also be developed by using the potential at Bui, higher up the River Volta. In discussing the present position of the project, the report states that it has always been contemplated that the International Bank for Reconstruction and Development might be associated with the scheme, and all concerned have agreed that the Bank should make a general assessment of the project and indicate the extent it might be willing to participate if agreement could be reached by the two governments and aluminium companies concerned.

Mechanical Engineering Research Report for 1955

THE Report of the Mechanical Engineering Research Board for 1955, which has been published by the Department of Scientific and Industrial Research and issued by H.M. Stationery Office, mentions that the slow progress in constructing the laboratory buildings for mechanisms and metrology and for heat transfer are causing concern. General remarks about hydraulic machinery building indicate that much of the equipment has been installed and that a closed circuit for cavitation research is under construction, and it is stated that air is being used in tests on models of pumps and turbines. In work on precision speed control electro-mechanical and two electrical systems are in use for dynamometer speed control and, according to the report, the electrical, accurate to better than 0·01 per cent, are simpler than the electro-mechanical systems. As part of the study of the basic principles underlying creep of structures the creep deflection of struts has been investigated and tests carried out on a magnesium alloy which has the creep properties at room temperature of heat-resistant materials at high temperatures. The report goes on to refer to research into the adhesion between locomotive wheels and rails with a view to increasing locomotive loads and improving acceleration and braking efficiency. The cause of variation in adhesion between wheel and rail is also being investigated at the laboratory, together with the effect of weather on slipping. Radio-active tracers are being employed to help in the detection of wear and also in the study of the behaviour of lubricants. Present investigations, the report states, are concerned with the suitability of lead sulphide as a lubricant under conditions of high temperature and pressure. Another subject of research is the efficiency of power transmission units and a prototype dynamometer having a capacity of 75 h.p. at 2000 maximum r.p.m. is now under test. Problems related to press and drop forging are receiving attention, and the report mentions that the laboratory is studying the mechanics of deformation of metals in compression caused by mechanical and impact loading and that the work is yielding information on the most effective kind of blow or series of blows to cause deformation. In the heat transfer section the efficiency of heat exchangers is one of the research items and the report records that at present data is being collected about the heat transfer to fluids ranging from gases to liquid metals.

The Engineer
100 Years Ago
(JULY 25, 1856)

"NEW WESTMINSTER BRIDGE"

"The select committee appointed to inquire into the state of Westminster-bridge, have had several sittings, and have already examined Mr. Page (the engineer to the Office of Works and the author of the plan), Mr. Rendel, Mr. Simpson, Mr. R. Stephenson, Mr. Fowler, Mr. Hawkshaw and Sir B. Hall. The general tenour of the evidence is against the mode of construction of the bridge, as not being likely to render the structure permanent; and it is probable that the committee will report to the House that it is not advisable to proceed further with the bridge according to the present plan.

"Sir B. Hall gave a history of the manner in which his attention was first called to the state of the bridge and the steps he took to arrive at the truth. After Mr. Mare's bankruptcy on the 25th of September last, the assignees proposed to carry on the contract, but they soon got tired of the work, and wished the Chief Commissioner to take it off their hands. This, however, he did not at first feel inclined to do. On the 7th of January last, a gentleman, whose name is not mentioned, called at Sir B. Hall's private residence, and directed his attention to the state of Westminster bridge, as not satisfactory. The Chief Commissioner the same day put himself in communication with Mr. Rendel, and afterwards associated with him Mr. Simpson. These gentlemen were then directed to institute a searching investigation as to the character of the works and the principles upon which the bridge was being constructed. Under their advice the works were stopped in March, and, according to their report, the wisest course will be to put up with the present loss, and begin the work anew. Mr. Rendel, Mr. Simpson, and Mr. R. Stephenson severally condemn the principle upon which the piers are being constructed as not being of a permanent character, and being likely to decay and subside. . . .

"The committee of public offices have unanimously recommended a much nobler and bolder plan, and should the House of Commons endorse this report with their consent, the site of the bridge will probably have to be changed. It is, therefore, perhaps a good thing that the works were stopped when they were, for had the bridge been much further advanced it is very doubtful whether the House of Commons would have assented to the throwing away of so much money. Fifty-seven thousand pounds is quite sufficient to lose without its being doubled."

Aswan High Dam

IT was announced last week, from Governmental sources in this country and in the United States, that British and American offers of financial aid for the proposed Aswan dam scheme in Egypt have been withdrawn. The decision to withdraw aid to Egypt was made on economic grounds, it is stated; there was some doubt of Egypt's economic capability of carrying through a scheme of such size. However, the decisions were evidently linked with other political factors. The dam would have been the keystone of a ten-year development plan in Egypt. Technically, the proposal was of special interest because of the necessity of sealing permeable sand and silt deposits, 650ft deep, upon which the dam was to be built. The principal preliminary data for the Aswan dam were given in a note in our issue of November 4th last, and in a leading article on February 17th we referred to some of the difficulties of dividing up the water resources of the Nile, between the various riparian nations, which the scheme brought to a head. The consultants for the scheme are Sir Alexander Gibb and Partners.

Fuel Research

THE reports for 1955 of the Fuel Research Board and of the Director of Fuel Research have now been published by H.M. Stationery Office. The progress of a wide variety of investigations is described. Work on coal has included gasification at temperatures above the melting point of the ash, i.e. 1500 deg. Cent. A cyclone chamber was used, high velocity gradients being an essential for the process. The cyclone combustion chamber for coal burning gas turbines is being developed by the B.C.U.R.A., and a design of chamber floor has been found which avoids the entrainment of slag droplets in the gas. The American classification of coals by "silica ratio" is being used as an assessment of their suitability for cyclone firing. Dust separators to treat the furnace output have also been tested: favourable results have been obtained with a few large elements instead of the accepted multi-cyclone cleaners. The atmospheric pressure straight-through combustion chamber is no longer to be developed, in view of the work proceeding at the N.G.T.E. on a similar unit working under pressure. A louvred-wall chamber built for oil firing has been investigated as a pulverised fuel furnace. Other work on solid fuel burning included establishing the importance of air tightness of operable stoves, and the development of a smoke eliminator for forced-draught hand-fired boilers. Absence of heavy fog restricted the gathering of information about pollutants in the open air.

It was found that in the Blackwall Tunnel, during heavy traffic, carbon monoxide concentrations rose as high as one in 2000, and while this is not dangerous for short exposures to normal persons, susceptible persons might be affected. The separation of sea water from fuel oil with surface-active agents was investigated with a view to safeguarding furnaces from salt, while the separators currently in use to recover oil from ballast or cleaning water are to be studied.

Report of the U.K. Atomic Energy Authority

JUST as we went to press this week the Second Annual Report of the U.K. Atomic Energy Authority was published. We hope to refer more fully next week to this document. The following is a very brief summary. At the end of the year (to March 31, 1956) under review no fewer than twenty-one nuclear reactors were either in operation, under construction or planned by the Authority alone. In addition to these a research reactor is to be built by a private firm. These are, of course, additional to the twelve nuclear power stations envisaged in the Government's ten-year programme. There are also other large research instruments, such as the 50MEV accelerator under construction at Harwell. Expansion of work is shown also by the fact that a second research site is under consideration, that a separate site has had to be taken for a large part of the isotope work, and that the Authority's staff increased by 30 per cent on the non-industrial side and by 13·6 per cent on the industrial side. Arrangements have been made both to maintain current uranium imports and also to secure the additional uranium which will be needed in the development of the British programme. Also in view of future demands, arrangements have been made to create additional capacity for production of graphite in the United Kingdom, while supplies of heavy water from other countries will be sufficient to meet all requirements. Further consideration has been given to adapting the process of thorium production to larger-scale production. Processes have been developed at Harwell for complete separation of U233, fertile thorium and the fission products from irradiated thorium. Great progress, it is reported, was made on the collaboration scheme with the four groups of industrial firms which is the starting point for the national programme of nuclear power. Although competing against each other for orders worth several millions of pounds, the four groups have been willing to meet regularly for the discussion of design problems and exchange of information. To co-ordinate major policy on design matters a nuclear power collaboration committee was set up. This has been attended by members of the Central Electricity Authority and more recently by representatives of the South of Scotland Electricity Board. It is revealed that research work into the possibilities of obtaining economic power from controlled thermo-nuclear reactions has been in progress for eight years—since 1948. "Extremely high" temperatures have been measured in experiments. To make a fusion reactor possible the nuclear fuel must be brought to a temperature in the region of 100,000,000 deg. Cent. It is not yet certain that a pure fusion reactor can be built which yields more useful power than it consumes. Universities and industry have helped in many aspects of this research. A new type of proton synchrotron accelerator is planned, with the object of producing about 100 times the intensity of present American machines and of a new machine nearly completed in the U.S.S.R. It is also announced that the United Kingdom Atomic Energy Authority has asked the A.E.I.-John Thompson Nuclear Energy Company, Ltd., to start preliminary work on the design and construction of a research reactor at the Atomic Weapons Research Establishment. The reactor will use light water as a moderator and coolant and will be designed for operating at power levels up to 5MW. Discussions on design and layout, particularly concerning the experimental facilities to be provided, have been proceeding for the past six months. Cooling of this reactor will be by air-blast coolers in the primary circuit. Certain constructional items associated with reactors, such as the biological shield and the reactor foundation, will be undertaken by the Ministry of Works for the U.K.A.E.A. This reactor will be used to obtain fundamental data required in the fields of weapons development and reactors for military purposes. Mr. Thomas Benson Gyles has been appointed by the Authority to act as a liaison officer with industry, and to advise on the uses to which these inventions might be applied and the terms (on a non-exclusive basis) under which they can be used.

F.B.I. Overseas Scholarships

THE Federation of British Industries has published the report on its overseas scholarships scheme, for the year ended March 31st last. By the end of that period, the report says, 107 scholarships had been awarded to overseas engineers from nineteen different countries, seven of them Commonwealth countries, nine in Latin America, and three in the Middle East. Eight more scholarships have been awarded since March, and, in addition to those countries which have already sent scholars to Britain, invitations have been extended to South Africa, East and West Africa and the West Indies, eight additional countries in Latin America and eight more in the Middle East. The report adds that, by the end of March, fifty-one scholars had completed their training and returned home. In a foreword to the report, Sir Arthur P. M. Fleming, chairman of the overseas scholarships committee, recalls that the scheme is based on the proposition that by training engineers from developing countries "we not only help them and their countries, but also ourselves." The growth of the scheme, Sir Arthur says, calls for increased training facilities in the United Kingdom, and he suggests that "there are still many engineering firms which could readily provide excellent training facilities for these young men, either alone or in association with others." Where necessary, he adds, the Federation of British Industries will gladly co-ordinate arrangements between works to ensure progressive and properly balanced courses of practical training. An appendix to the report contains a list of 109 firms, engaged in all branches of engineering in this country, which are now taking part in the overseas scholarships scheme.

120MW Reheat Sets in C.E.A. Power Stations

WE learn from the Central Electricity Authority that the Minister of Fuel and Power has approved the installation, in the new power station to be built on the Trent at Rugeley, of two 120MW turbo-generator sets, instead of four 60MW sets originally authorised in July of last year. This change results from a review of the generating plant programme which has been undertaken by the Authority and represents a development which will affect the proposed plant installations in five new power stations. Subject, in certain cases, to the Minister's consent, twenty-six sets of 60MW each, which were planned for installation in these stations, are to be replaced by thirteen sets of 120MW each. The other stations, in addition to Rugeley, in which it is proposed to substitute these larger sets, are Staythorpe "B" (for which the plant has already been ordered), Skelton Grange "B," Uskmouth "B" and Belvedere. The C.E.A. states that some delays will occur in the planned commissioning dates for the plant in these stations and arrangements are being made to make up the consequent loss of capacity, by accelerating the installation and advancing the commissioning of 60MW units in other stations in the C.E.A. programmes. This change in the plant programmes has been made possible by the development of the design of the 120MW reheat set, in conjunction with the evolution of improved operating techniques to the stage where it is considered that these sets can be used for two-shift loading at a relatively early stage of operation. It is estimated that substantial economies in capital costs will be effected by the substitution of the 120MW sets, not only in the plant itself, but also in the cost of the main buildings and civil engineering works, including the circulating water system. Moreover, the larger sets will be considerably more efficient in thermal performance than the 60MW sets and will yield a substantial saving in the amount of fuel required, an advantage that is accentuated by the recent increases in the price of coal. In accordance with the trend towards the adoption of larger generating sets in the new power stations under construction and planned, few further 60MW sets will be installed by the Authority, except where circumstances preclude the installation of the larger sizes.

Air Registration Board

THE nineteenth annual report of the Air Registration Board covers the year ended March 31, 1956. In the introduction, Lord Brabazon of Tara draws attention to the importance of stress corrosion cracking, and to the desirability of using materials which are not exacting as to processing; he is apprehensive of attempts to operate at the limit of technical possibility. Agreements between this country and the United States of America are reported, under which U.S. aircraft, to gain British validation of airworthiness certificates, will require fire extinguishing equipment to Civil Airworthiness Requirements, and a common basic type test for gas turbine will be recognised for civil and military purposes. Representatives visited Santa Monica to discuss the validation of Douglas "D.C.6" and "D.C.7c." aircraft, and Paris in connection with validation of the Breguet "Deux Ponts." A new issue of Section D—Aeroplanes—of British Civil Airworthiness Requirements was made on the 1st of this month, and is extensively revised. Amendments agreed with the British Gliding Association will call for a reissue of Section E—Gliders. The report welcomes a trend to closer liaison between aircraft and equipment constructors, leading to the supply of a component for a particular purpose, instead of the purchase of an "Approved" accessory. Reference is made to the lack of prospective airline pilots, hitherto recruited from ex-R.A.F. crews of four-engined aircraft, and suggests the establishment of aviation scholarships for those with aptitude for this specialised task.

Modern Dewatering Methods in Irrigation Problems

By S. LELIAVSKY, Ph.D., M.I.C.E., M.Am.Soc.C.E.

No. I

The well-point type of enclosure dewatering has nowadays become standard routine in building foundations of hydraulic works in the channels of alluvial rivers. One of the characteristic differences between this modern system and the earlier one of open pumping, consists in that the capacity of the latter is fairly elastic and can be supplemented in the course of the work by additional units, without causing much trouble ; whereas the extension of the capacity of a well-point layout may possibly constitute a much more difficult problem. Many rules and formulas have therefore been produced, permitting the calculation of a well-point scheme beforehand. They are briefly reviewed in the following article. Practical hints bearing on the choice of the system according to the local conditions of each particular case, are given at the end of the article.

(*a*) Introductory

THE two photographs, Figs. 1 and 2, illustrate the "march of time" as reflected in the evolution of dewatering methods, for they were taken at almost the same spot—at the Esna barrage, on the Nile—at an interval of some forty years ; the first one, during the construction of the barrage, in March, 1907 ; the second, during its remodelling—in March, 1946. In 1907, the unwatering was done by pumps installed on bottomless wells, three of which are clearly seen in the picture. The pumps discharge into a common timber trough, which carries the water away from the enclosure. The second photograph shows the collector of the Moretrench well-point system, used for the dewatering of the enclosure, during the remodelling of the foundations of the same barrage. It draws water directly from the subsoil, by means of a number of vertical filter wells (described as "well-points"), sunk to the required depth into the ground. The lower portion of such a well is a perforated pipe with a gauze, or mesh, of some description or other, to prevent the soil particles from being carried into the perforations. The object performed by such a system of wells is to "suck" the ground water from the lower layers of the soil, before it reaches its surface, and by these means lower, depress, or "draw down," the ground water level. The foundations can then be built almost "in the dry."

The idea was not new. It had already been applied earlier in various countries on the European Continent. For instance, A. I. Lebedeff used this system, in 1918, for the construction of lock No. 4 on the Don River, in Russia (see Fig. 4).

Apart from the "collector" type illustrated in Fig. 2 there are also other systems of dewatering based on the same principle, in which every pipe is provided with its own operating pump.

This pump may either be placed above ground level and will then work by suction (as in the Moretrench system), or it may be located in the well itself, below water level, and its action is then positive. Fig. 6 is an example of the latter type. Fig. 5 shows the pumps used by the author, in 1936, in reconstructing the Roda Island Nilometer.[1] The pumps and motors were supplied by Escher, Wyss and Co., Zurich, with whose agreement the drawing is reproduced. The electrical motor was placed above ground and connected with the pump by an elastic axle. Six such motors are seen in Fig. 5.

(*b*) Basic Principles of a Dewatering Calculation

With the older system, pumping power could easily be—and frequently was—materially increased in the course of the work, if the seepage discharge filtering into the enclosure was greater than had been expected, for pumps and motors of the common class are always available on the market. The case, however, is quite different with specific types of well-point systems, for these must be ordered in advance ; also, their equipment cannot afterwards be disposed of as easily as that of the current type of pumps, and should, therefore, the capacity of the installation be much greater than actually required, unnecessary expenditure on that item will be a heavy burden on the total cost of the works.

This difference explains why it is that, whilst unwatering schemes of the open type are seldom referred to as a specific subject in textbooks, the well-point system has been dealt with extensively in various publications,[2] particularly as the relevant theory includes also the case of the deep wells which are used for the water supply of towns, small irrigation schemes, &c. The time-honoured formula of A. Thiem[3] forms the starting

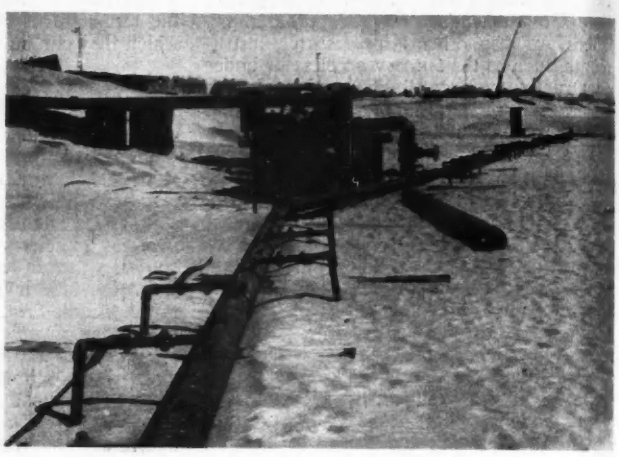


Fig. 2—Esna barrage. Dewatering equipment, 1946

[1] S. Leliavsky Bey, "Underpinning and Repairing the Roda Island Nilometer," THE ENGINEER, December 9 16 and 23, 1949.

[2] Kyrielis and Sichardt, "Grundwasserabsenkung bei Fundirungsarbeiten," Berlin, 1930. W. Sichardt, "Das Fassungsvermögen von Rohrbrunnen . . .," Berlin, 1928. J. Schultze, "Die Grundwasserabsenkung in Theorie und Praxis," Berlin, 1924. Baich, "Hydraulics of Deep Wells," *Journal A.W.W.A.*, 22, 727, 1930, and many others.

[3] Thiem, "Über die Ergibigkeit artesischer Bohrlöcher . . .," Zeitsch. Gasbel., 1870.

Fig. 1—Esna barrage. Dewatering equipment, 1907

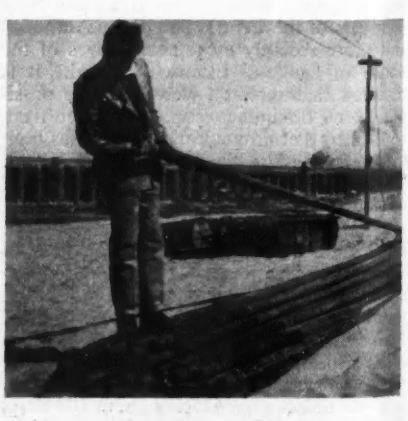


Fig. 3—Perforated pipe

point of this analysis, just as the Dupuit equation lies at the origin of the theory of percolation through earthen banks.

Thiem imagines a radial flow converging towards a central axis (see Fig. 7).

The surfaces of equal potential are in this

Fig. 4—Early use of well-point system of dewatering. Construction of lock on Don River, 1928

case concentric cylinders. For each cylinder we have, according to d'Arcy's law,

$$v=\alpha\frac{dz}{dx},$$

in which

- v is the velocity, or more precisely, the discharge divided by the area of the cylinder,
- z is the height of the saturation surface above the impermeable subsoil,
- x is the distance from the well axis to the point,
- α is d'Arcy's coefficient.

Since the effective area is $2\pi xz$, the discharge is found to be

$$q=2\pi xzv=2\pi xz\alpha\frac{dz}{dx}.$$

Hence,

$$2zdz=\frac{q}{\pi\alpha}\frac{dx}{x}.$$

Intgerating

$$z^2=\frac{q}{\pi\alpha}\,lg_e\,x+C.$$

On the surface of the perforated pipe x is equal to r_0 (radius of the pipe) and z is the same as h_0 (depth of water in the pipe). Thus,

$$z^2-h^2=\frac{q}{\pi\alpha}(lg_e\,x-lg_e\,r) \quad . \quad . \quad (1)$$

It will be remembered that the hydromechanical problem we are dealing with now belongs to the realm of the potential flow theory, with the difference, however, that we are here concerned with a particular case of its application in practice. Thus, although according to abstract theory the depression of the water surface, caused by a well, extends to infinity, in practice we must admit that its effect is limited to a certain radius R, in which case the formula (1) changes into

$$H^2-h_0^2=\frac{q}{\pi\alpha}(lg_e\,R-lg_e\,r) \quad . \quad . \quad (2)$$

We shall discuss later on the question of how to determine R, but for the present it may be of interest to mention that Thiem's formula (1) for radial flow and Dupuit's equation for parallel flow, are both particular cases of a more general equation for the ground water surface, given by Forchheimer. In fact, if z is the height of this surface measured above a certain datum, and x and y are the horizontal co-ordinates of a point, then according to Forchheimer[4]

$$\frac{\partial^2(z^2)}{\partial x^2}+\frac{\partial^2(z^2)}{\partial y^2}=0.$$

If z^2 is a function of the co-ordinates x and y

$$z^2=f(x,y),$$

then any solution satisfying Laplace's equation,

$$\frac{\partial^2 f(x,y)}{\partial x^2}+\frac{\partial^2 f(x,y)}{\partial y^2}=0,$$

represents a physically possible case of subsoil water flow. Also, if we have a number of such solutions,

$$z^2=f_1(x,y)\;;\;\; z^2=f_2(x,y)\;;\;\; z^2=f_3(x,y)\ldots$$

then by summing them up we obtain another possible solution,

$$z^2=f_1(x,y)+f_2(x,y)+f_3(x,y)+\ldots=\Sigma_n f(x,y).$$

Thus, generally speaking, we are dealing with problems of potential flow, as expanded in the mathematical theory of percolation, and the various solutions of Laplace's equation are fully applicable. To attempt, however, the calculation and design of a dewatering system—which may frequently include hundreds of wells—from the pure theory of potential flow, including all its conventions, would not only be extremely laborious, but also senseless, because the limits of application of this theory depend, in this case, on empirical rules, based on considerations lying beyond its scope. As frequently occurs in similar cases, the empirical rules in question differ from country to country, and, sometimes, from designer to designer; particularly where patented systems are concerned. A particularly useful collection of such information is given in W. Sichardt's well-known publication,[5] reference to which is recommended.

We will first consider the basic empiric factors of the solution, such as the radius of influence R, the maximum yield Q, &c.

(c) The Circle of Influence of a Well-Point

The effective radius R of a well-point (see Fig. 7) is variously described by different authors as half the width of the depression, the influence radius, or the radius of the influence circle. It appears in the right-hand side of equation (2), which may be rearranged in such a manner as to bring out the influence of this factor on the discharge, namely,

$$q=\pi\alpha\frac{H^2-h_0^2}{lg_e\,R-lg_e\,r_0}.$$

[4] Ph. Forchheimer, "Grundwasserspiegel bei Brunnenanlagen," Zeitschr. d. Ost. Ing. u. Arch.-Ver., 1898.

[5] Kyrielis and Sichardt, "Grundwasserabsenkungen bei Fundierungsarbeiten," Berlin, 1930.

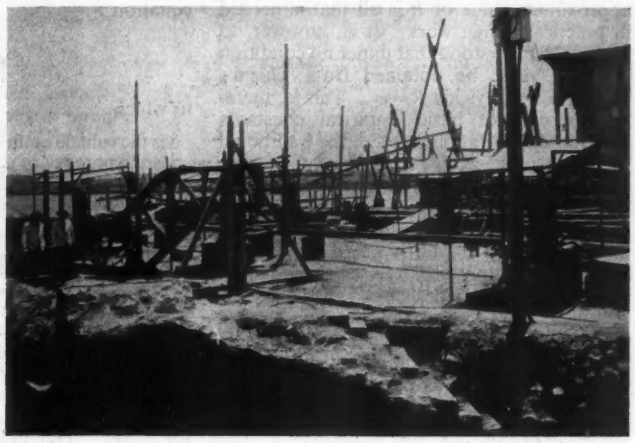


Fig. 5—Arrangement of pumps used by author in reconstructing the Roda Island "Nilometer"

Given $\delta=H-h_0$ (see Fig. 7), q decreases as R rises, but only very slowly, e.g. for a 100 per cent difference in the value of R, the reduction in q is only 10 per cent, which may be disregarded, as compared with the error due to the uncertainty in the value of the coefficient α. It therefore follows that an

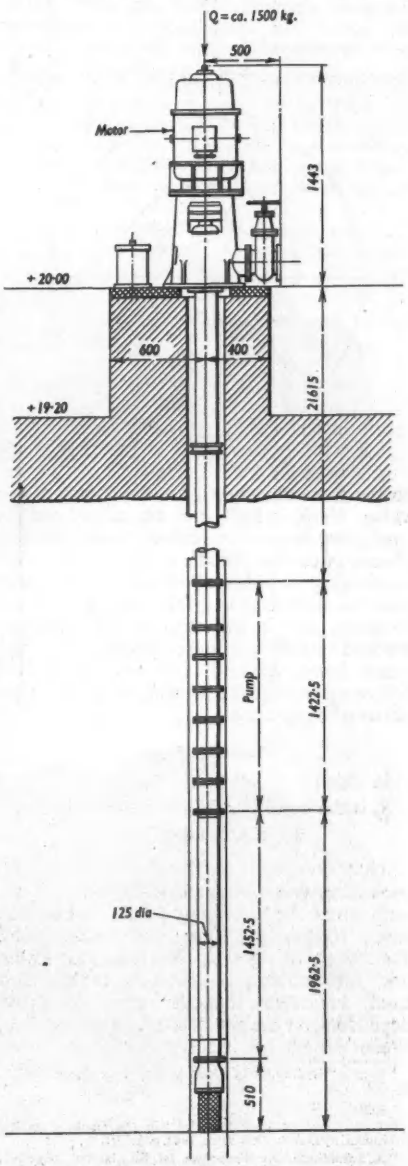


Fig. 6—Arrangement of pump and drive for well-point system

approximate value of R is all that is needed in practical design work. It is, however, to be clearly understood that under no condition can this value be obtained from Thiem's theory, for this yields $R=\infty$. This is, therefore, a case of basic empirical constants conditioning the application of the traditional theory to practice.

It is frequently believed that owing to the well-known inconsistency in the available field data on the subject, R cannot be determined from observations made in Nature.[6] Arbitrary assumptions have therefore been suggested by some designers; for instance, R was assumed to be 200m, because, beyond this limit, further increase does not materially affect the result.[7] Another approach is to take the value of R as the distance from the well, at which the depression $H-h_0$ becomes negligible.[8] This method, however, is open

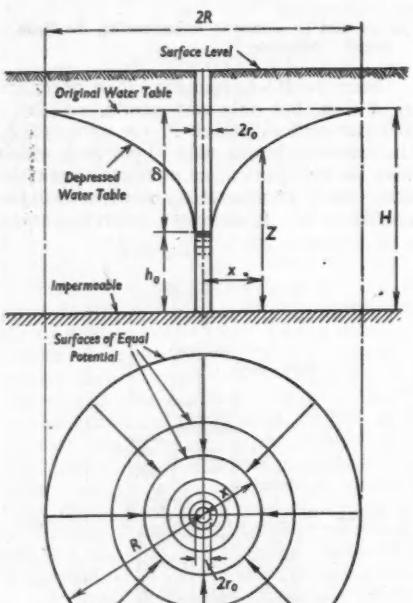


Fig. 7

to the same objections, for the choice of the value $H-h_0$ which can be considered as negligible, is another abitrary assumption—unless, of course, specific evidence is supplied confirming its practical consistency, in which case the field data will form the basis of the solution, and it will then be an empirical method based on observations. On the other hand, Sichardt (*loc. cit.*) gives the following empirical equation, based upon his personal experience :—

$$R=3000\ S_0\sqrt{\alpha},$$

in which

S_0 is the depression $H-h_0$ at the well-point

α is d'Arcy's coefficient.

That R depends on the nature of the soil, increasing with α, is supported by Schoklitsch, who gives the following values :—For fine sand, $R=5$m to 10m; for rough sand, $R=50$m; for gravel, $R=100$m to 150m, and for pebbles, $R=500$m.[9] It has also been suggested that R must be made dependent on the time factor. For instance, Weber's method[10] is based on the following equation :—

$$\beta N=\int_0^{\tau} q\,dt$$

in which

N is the volume of the depression,

β is the porosity of the soil,

τ is the time period from the beginning of the pumping operation,

dt is the time element,

q is the discharge.

Contrarily to Thiem's method, which assumes implicitly that the discharge is constant, Weber considers the case in which the discharge varies both in time and in space, namely, he postulates that at a distance $r=R$ from the well, the discharge is negligible, but that it rises gradually as the radius r decreases and attains a maximum value q, for $r=r_0$. Transcribed in the form of an equation, this postulate takes the form

$$q_r=q\left[1-\left(\frac{r}{R}\right)^n\right],$$

in which n is an exponent that must be determined.

Under these assumptions, Weber finds for R the following equation :—

$$R=c\sqrt{\frac{H\alpha T}{\beta}}$$

in which

$$c=4(n+2)/n.$$

In comparing this formula with actually executed dewatering operations, Weber concluded that the exponent n was not constant but depended on the time factor, varying between 1 at the beginning of the pumping and 2 at its end. This, however, had a small effect only on the results of the calculation, the corresponding extreme values of c being 2·82 and 3·2, with 3·00 as an approximate average.

For the discharge (in a zone not very far from the well) Weber finds the following approximate formula :

$$q=\frac{\pi\alpha(H^2-h^2)}{lg_e R-lg_e r-1/n},$$

which he recommends for use, instead of Thiem's equation (2). Note that for $n=\infty$ the two equations are equivalent.

(*d*) Yield of a Well-Point

Another important factor on which the layout of a dewatering system depends is

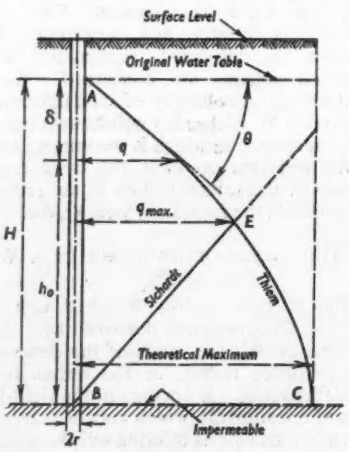


Fig. 8

the maximum discharge of a well, i.e. its "yield." Here, again, theory alone is unable to supply the required result; in fact, it would appear from the theoretical equation (2) that in order to obtain the maximum effect from a well, i.e. the greatest possible discharge, the depth of the water in the well, h_0, must be reduced to zero. This result, however, is absurd, because the effective surface area of the perforated pipe filter through which water penetrates into its interior, is then also zero, and this could only happen if the velocity were infinite. It follows that h_0 cannot be zero. Its minimum value, yielding the greatest possible discharge, must then be found from empirical equations, which qualify and control the application of the theoretical formula (2).

Let AB (see Fig. 7) be the axis of a well and let the curve AEC represent the theoretical discharge, q, for various values of h_0, as calculated from formula (2). The length BC represents then, to scale, the theoretical discharge obtained by inserting into this formula $h_0=0$. As this was shown to be impossible, another solution must be employed to determine the true value of *q maximum*. For instance, according to Sichardt, (*loc. cit.*) we may assume that whatever amount of water is pumped from a well, the average radial velocity of the water on the periphery of the perforated pipe cannot exceed a certain maximum, depending on the nature of the soil; namely :

$$V_r=\frac{\sqrt{\alpha}}{15},$$

in which V_r and α are both in metres and seconds. Accordingly :

$$q=2\pi r_0 h_0\frac{\sqrt{\alpha}}{15}.$$

This equation supplies the straight line BE in Fig. 8. It is, therefore, evident that the maximum discharge obtainable from a well is represented by the point E, in which the curve meets the straight line. The corresponding water level is then given by h_e.

Substituting this in (1) and using the letter f to denote the practically possible maximum discharge q, that is, "the yield" of a well,

$$f=\pi\alpha\frac{H^2-h_0^2}{lg_e(R/r_0)}$$

or

$$H^2-h_0^2=\frac{2h_0 r}{15\sqrt{\alpha}}lg_e\frac{R}{r_0}$$

solving for h_0

$$h_0=-\frac{r}{15\sqrt{\alpha}}lg\frac{R}{r_0}+\sqrt{H^2+\left(\frac{x_0}{15\sqrt{\alpha}}lg_e\frac{R}{r_0}\right)^2}.$$

This formula can serve another purpose also : namely, it will supply the minimum possible diameter of the pipe, $2r_0$.

(*e*) Interference of Several Wells

Mutual interference of the wells is still another practical consideration on which depends the design of a dewatering system. Here again, particularly interesting theoretical solutions are available, supplied mainly by Forchheimer; but what is needed in practice is not an elaborate estimate of the equipotential surface corresponding to a hypothetical well arrangement, but a simple rule for spacing the wells in such a manner that their individual discharges should not be materially reduced. According to Sichardt this result is attained if the distance, b, between the centres of two neighbouring wells is at least equal to $5\times 2\pi r$, i.e. about fifteen diameters; thus $b_{min}=31\cdot 5r$.

(To be continued)

[6] Balch, "Hydraulics of Deep Wells," *Journal, A.W.W.A.*, 22, 727, 1930.

[7] Ibid.

[8] T. R. Camp, "Water Supplies," in *Handbook of Applied Hydraulics*, by Davies, New York, 1943, page 701.

[9] A. Schoklitsch, *Der Wasserbau*, 1st. Ed., 1st Vol., page 172.

[10] H. Weber, "Die Reichweite von Grundwasserabsenkungen," Berlin, 1928.

Rocket Power Plant

The "Screamer" is a rocket engine which is readily started, stopped and controlled, one combustion chamber only being employed. Unusual features are a throatless chamber and a tri-propellant system—fuel, oxidant, and coolant.

THE first liquid fuel rocket motor to be flown in this country was the Armstrong Siddeley "Snarler," which gave 2000 lb thrust at sea level. It was flown in the tail of a Hawker "Sea Hawk" in 1950 and 1951, and illustrated in these columns on September 18, 1953, page 376. It was a bi-propellant motor, using liquid oxygen and water/methanol as fuel.

Its successor, the "Screamer," is a tri-propellant plant, liquid oxygen again being the oxidant, kerosene the fuel, and water the coolant. The engine is essentially self-contained, fuel transfer being effected by pumps driven by a turbine running on gas generated by decomposing the same three liquids.

In its earliest stages, the "Screamer" was distinguished by a combustion system intended to burn kerosene in oxygen gas. The combustion chamber was situated downstream of an evaporator in which a very weak mixture of liquid oxygen and kerosene was burnt. The resulting mass of gas, principally oxygen, passed into the combustion chamber around a nozzle spraying kerosene under pressure through many small holes. The evaporator was stainless steel, and water cooled. The combustion chamber was mild steel, and cooled by water led by guides along a helical path from the tail cone to a station opposite the fuel nozzle, where it was passed into the chamber by a ring of small holes nearly tangential in direction. This intriguing combustion system was not, however, adopted.

The present combustion chamber is throatless, and has proved largely free from instability, although the unit has lived up to its name when running at low powers. While some of the earlier chambers were cooled entirely by conduction, the water being led over the surface by spiral guides, the present pattern, illustrated in Fig. 3, is film cooled. Water enters at the rear of the tail cone and runs up to the junction with the chamber proper: it is then collected and piped to the head of the combustion chamber, and fills the annulus between the double walls. The clearance between the walls is preserved against distortion due to uneven heating by longitudinal spines. The water is passed from the annulus into the chamber by five bands of small drillings, the bore of the outer shell being reduced opposite the three bands within the length of the chamber, so that the speed of flow varies little. The walls of the chamber are entirely mild steel.

The combustion chamber illustrated is a plain showerhead design; the kerosene enters through sixteen radial lines of seven holes, between each set there being twelve oxygen jets. During development work, other designs were tried, in particular schemes in which sets of fuel nozzles impinged, but it was concluded that turbulence in the chamber was so high that no advantage was gained. Pre-mixing of liquid oxygen and kerosene was rejected, and the chamber was too small to permit swirl nozzles to be tried.

The chamber is lit by a dual igniter, kerosene being supplied to the sparking plugs and liquid oxygen pumped between them.

A smaller combustion chamber, similar in essentials, forms the gas generator for the turbine. The gas generator is fed with water as well as oxygen and kerosene in such proportions as to give a gas temperature acceptable to the turbine: otherwise, the gas generator would either have to run very rich, with a possibility of sooting up the turbine or the exhaust catching alight, or very weak, introducing a hazard of burning of turbine blades or other hot parts. The gases are fed from the generator into three nozzles facing the single stage impulse wheel, the blades of which run supersonic. From the aft face of the turbine, two prominent exhaust ducts lead away below the engine. The turbine runs at 20,000 r.p.m. at full power, and drives the liquid oxygen, kerosene, and water pumps at speeds close to this.

About half the turbine power is taken by the liquid oxygen pump, which consumes about 200 h.p. at full load. It is a single stage centrifugal pump with a straight-bladed 3½in impeller, preceded by a three-bladed screw inducer which serves to lower the acceptable minimum intake pressure. The impeller delivers the liquid into, not a volute, but an annular collector ring: this configuration results in a very flat pressure/flow characteristic. Behind the rotor is a gland consisting of a mild steel ring on the face of which is sintered 0·025in of mild steel impregnated with p.t.f.e., spring loaded into contact with a ring of stainless steel: this gland, running at 20,000 r.p.m. and having a diameter of 1⅛in, is resisting a pressure of 30 lb to 40 lb per square inch. The rolling bearings of the pump are guarded by a normal oil seal, and between this and the liquid oxygen seal are two separate slinger rings, each with its own drain.

The pumps for water and kerosene are smaller, and there is no need for such elaborate precautions against lubricating oil reaching the working fluid.

The rocket engine is started up by activating the turbine and pumps, and for this purpose small tanks of water, kerosene, and liquid oxygen are installed aft of the bulkhead. The near-spherical water tank is prominent in the illustration, and the oxygen tank, black and cylindrical, can be seen beside the combustion chamber; the liquid oxygen is expelled by a piston. When the pilot first moves the control lever, nitrogen under pressure forces the liquids from the tanks into the gas generator igniter, and the spark coil is energised. As soon as a rise in pressure in the igniter signals combustion, the gas generator is fed with coolant, oxidant, and fuel, and the turbine runs up to speed.

Control System

Once the turbine-driven pumps are developing pressure, the nitrogen will be vented from the starting tanks and the pumps alone will supply the gas generator, the liquid oxygen passing through the pilot's control valve, which will be discussed in more detail later. As soon as coolant pressure is available, the combustion chamber igniter is supplied with fuel and oxidant. Assuming ignition takes place within the two seconds allowed, the resulting rise of pressure triggers the supply of coolant to the combustion chamber; this, in turn, starts the liquid oxygen supply, and oxygen pressure is the signal for the fuel valve to open.

In practice, this sequence is followed so rapidly that the combustion chamber is on power while the turbine is running off the starting tanks, and since these tanks discharge without restraint by the pilot's control lever, the initial impulse from the motor is always high, even if the control lever is set for a low thrust. The method of regulation of output is basically simple; the pilot's control varies the setting of a spring-loaded reducing valve in the liquid oxygen supply to the gas generator. A pressure balance valve continuously keeps the water and kerosene supply pressures equal to the oxygen pressure, and thus the output of the generator follows the pilot's control. The mass flow through the generator determines the turbine speed, and, hence, the liquid oxygen pump delivery pressure; another pressure balance device brings the fuel and coolant supplies to the combustion chamber to that same pressure. The oxidant delivery pressure therefore governs the flow through the combustion chamber and the thrust. The gas generator supply pressure is sufficiently far below pump output pressure for there to be no likelihood of, say, a

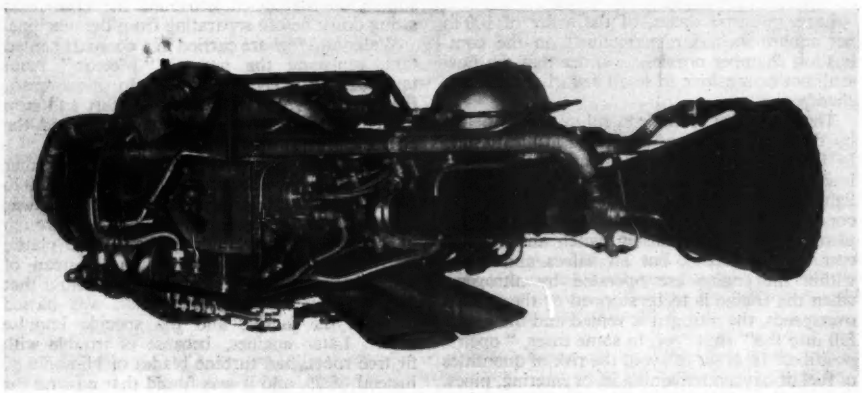


Fig. 1—The "Screamer": the drum behind the engine mounting contains the dual ignition coils, while in front of the bulkhead is the oil tank

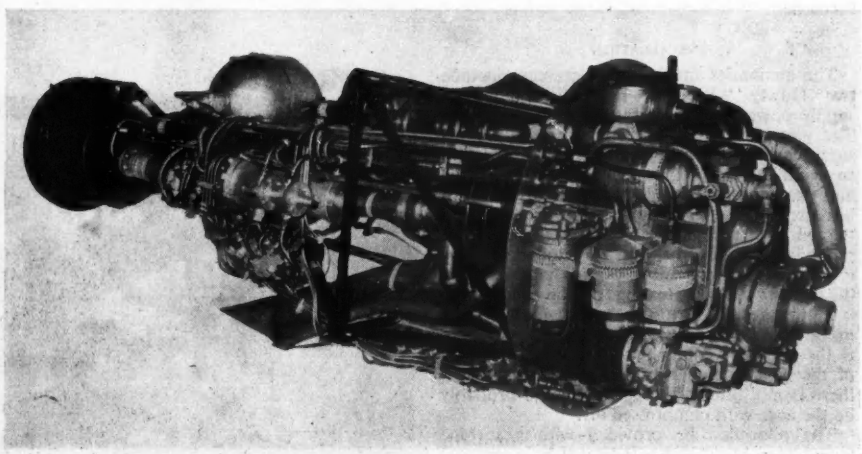


Fig. 2—In this view the gas generator obscures the front of the combustion chamber, and the ducts leading to the turbine can be seen; beside the generator is its pressure balance valve. Prominent in front of the gear case is the liquid-oxygen pump

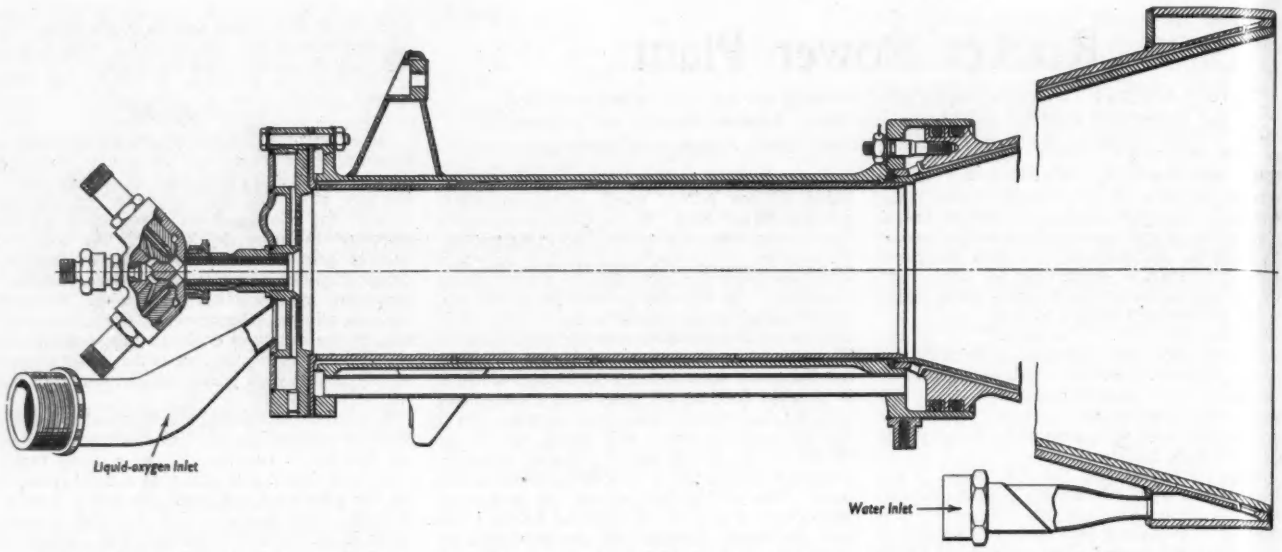


Fig. 3—Section through effusion cooled combustion chamber. The dual igniter is water cooled and has high-frequency surface-discharge spark plugs

drop in gas generator output reducing the pump delivery and this affecting the generator supply, the control system thereby becoming unstable.

It was originally intended that a centrifugal all-speed governor should be fitted to the turbine, and control the gas generator oxygen supply to give the thrust set by the pilot. This was found unnecessary, as also was a second pressure balance device downstream of a set of metering jets, which would have avoided any change in mixture strength due to blockage or erosion of the nozzles. The combustion chamber runs on about 62 per cent oxygen, 24 per cent kerosene, and 14 per cent water, the proportion of water rising at lower thrusts ; the gas generator consumes mainly water.

Large pressure drops, of the order of 100 lb per square inch, are maintained on the combustion chamber nozzles, in order that the flow shall not be sensitive to small disturbances in the chamber.

The simplicity of the control system is belied by the proliferation of pipes and fittings visible in Figs. 1 and 2. The apparent complexity is due to the fact, mentioned in the account of lighting up, that each stage in the operation is conditional upon the previous one being completed. The pilot's master switch and starting control are electric, but all valves and relays within the engine are operated by nitrogen : when the engine is to be stopped or the turbine overspeeds, the nitrogen is vented and the valves fall into the " shut " or, in some cases, " open " position. In order to avoid the risk of quantities of fuel or oxygen remaining in, or entering, pipes, and causing explosions at starting up, the pipes downstream of the main stop valves are purged with nitrogen—into the combustion chamber in the case of oxygen, overboard in the case of kerosene.

Installation

The auxiliaries fitted on the gearcase include two Dowty " Vardel " hydraulic pumps to supply power to the aircraft, but no generator. The aircraft's liquid oxygen tank would pressurise itself, and be provided with a booster pump to avoid boiling in the pipelines, while the fuel and water tanks would be pressurised with nitrogen. The engine, by virtue of flap valves in the oil tank and anti-*g* valves in the scavenge pump suction, can be operated under negative *g*, and similar provision would be needed in the aircraft tanks. Heating of the water tank is anticipated if the motor is used for anything more than assisted take-off purposes. Nitrogen is the chosen medium for services, since much of the engine is so cold as to cause trouble if there is moisture in the gas, as would probably be the case with compressed air.

The pilot can be provided with a turbine tachometer, but thrust is indicated by a pressure gauge on the combustion chamber, a correction being necessary, of course, for altitude.

The " Screamer " passed a flight clearance trial for thrusts between 2000 lb and 4000 lb in December last, the trial involving some seventy starts. The engine used was intended for flight trials in the " Meteor " VIII illustrated ; this engine was built with the front of the combustion chamber raised to an angle of about 10 deg., to allow the engine to be installed underneath an aircraft. The engine is recessed slightly into the underside of the fuselage, the new skin and the mounting rails being stainless steel. Immediately in front of the engine a liquid oxygen tank, consisting of two near-cylinders in a streamlined shell, is carried on the normal ventral tank release mechanism ; a framework on the rear of the tank abuts pivots on the front of the engine, so that when jettisoned the tank must swing down before separating from the machine.

Water and fuel are carried in a compartmented tank replacing the normal " Meteor " main tank above the centre section. In this aircraft, the pilot has separate buttons to start and stop the engine as well as a throttle lever, and the engine can be started at any thrust setting.

The power plant was subsequently further developed to provide thrust over the range 800 lb to 8000 lb. In this advanced form water was injected into the combustion chamber through a narrow gap surrounding the nozzle plate ; since the water was driven along, instead of away from, the chamber wall, it was found that less water need be injected than was passed through the jacket, and the specific impulse rose. Later engines, because of trouble with fir tree roots, had turbine blades of Nimonic 80 instead of 75, and it was found that passing the steam through one nozzle instead of three greatly improved blade life.

The " Screamer " accumulated about thirty-six hours' running after its first start in March, 1954. Development has ceased as a result of a Ministry of Supply decision that there is no Service requirement for a liquid oxygen engine of this type.

Research on Boiler Availability.—The Boiler Availability Committee, 8, Waterloo Place, Pall Mall, London, S.W.1, has published a reprint of the paper " The Work of the Boiler Availability Committee Since the Fuel Economy Conference at The Hague in 1947," by Mr. H. E. Crossley ; the paper was originally presented at the Fifth World Power Conference. It gives an account of investigations to correlate the external fouling of boilers with the chlorine content of the coals burnt, and then deals with developments arising from theories about the formation of sulphur trioxide in flue gases, and experiments concerned with the reduction of this compound by carbon or adsorption of it on smokes of carbon or zinc. There is then a description of developments in the techniques used in the investigations, such as the use of the dewpoint meter and cooled steel probes for the testing of flue gases, and the improvement of methods for the analysis of boiler deposits. The most important methods of alleviating fouling or corrosion trouble have been the efficient cleaning of boiler plant on load and off load, the recirculation of flue gas to the combustion chamber, the burning of pulverised coal above fuel beds on mechanical stokers and the humidification of combustion air. The paper concludes with discussion of the progress made by the Boiler Availability Committee and of fouling and corrosion problems which may arise in the future.

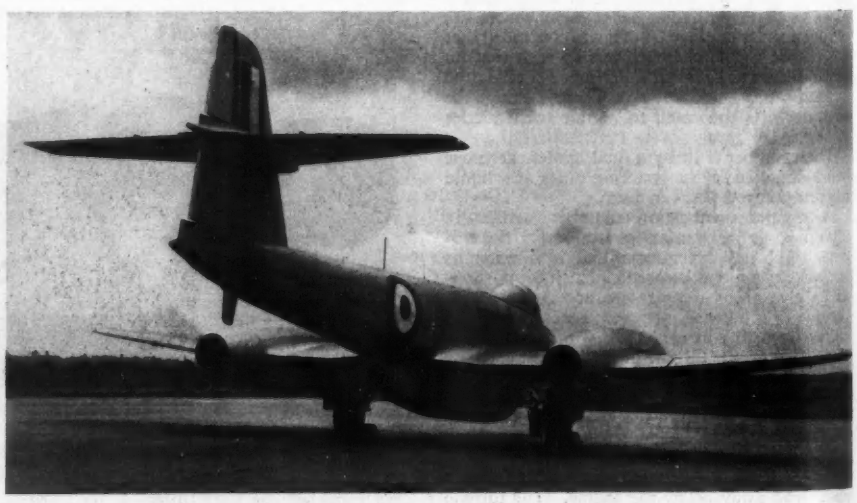
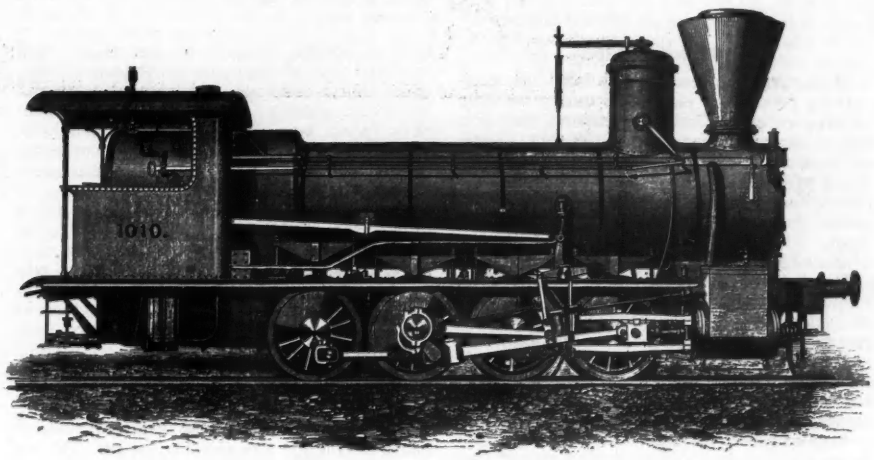


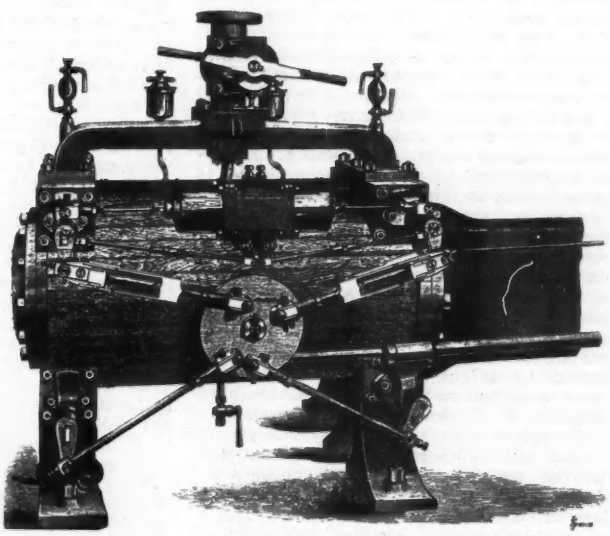
Fig. 4—The " Screamer " installed under a " Meteor' VIII. Notice the air-cooled stainless steel sheath under the fuselage and the new tail bumper

ENGRAVINGS OF 1873

The eight-wheeled goods engine, illustrated in the right-hand engraving, was built for the Southern Railway of Austria, and was described in our issue of May 30, 1873. It was one of the locomotives required to haul trains over the Semmering Alp, and the article comments that "it is no very easy task to conduct the regular traffic of a great railway over an incline of 1 in 40 for twenty miles." The weight of the engine in running order was 50 tons 10 cwt.

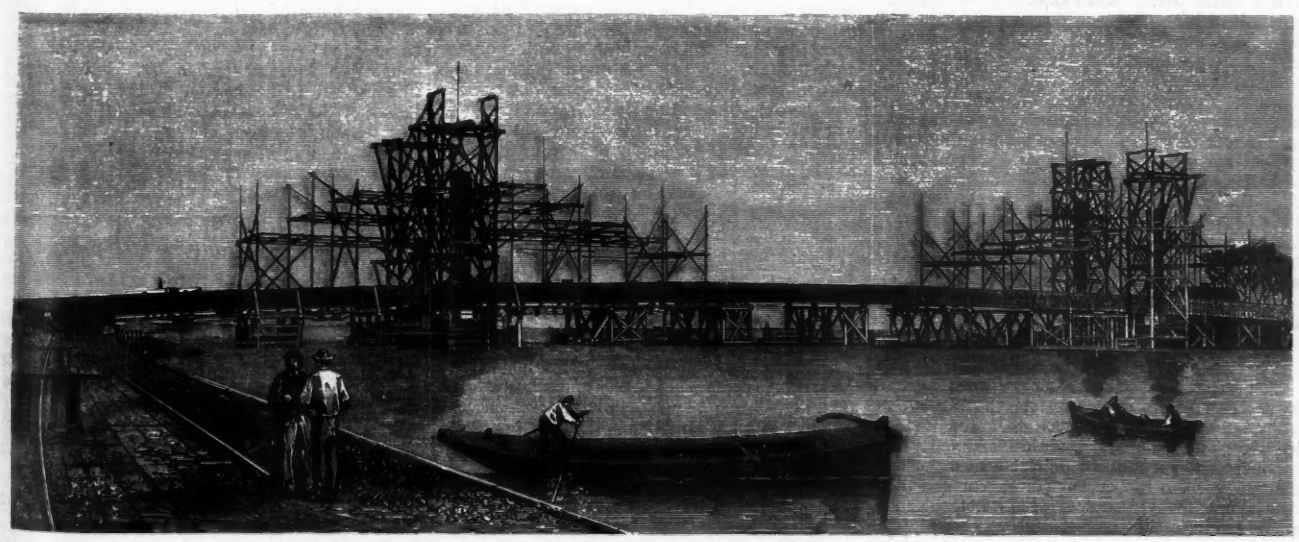


On the left below there is reproduced from our issue of May 16, 1873, an engraving showing a portable mine winding engine built by Alexander Chaplin and Co., of Glasgow. The engine was of 15 h.p., with two cylinders 8in diameter and 14in stroke. The 5ft diameter drums, one each side of the boiler, were "placed upon independent shafts worked by spur gearing."



The Corliss engine, shown in the engraving above, was described in our issue of January 10, 1873. The engine, which was installed in some flour mills near Waterloo Bridge, was built by Hick, Hargreaves and Co., Bolton. The cylinder diameter was 20in and the stroke 4ft.

The scaffolding used in erecting the columns and ties of the Albert Bridge, over the River Thames, is illustrated below. The engraving is taken from our issue of February 7, 1873. The description notes that "the main girders and platform are supported upon the temporary staging underneath, which was originally not intended for so heavy a load!"



Metallurgical Topics

Hydrogen in Steel

HYDROGEN retained in steel from the steelmaking process or picked up during welding, pickling or electroplating operations, may give rise to several different types of defect. Some of these are referred to in a short review published by E. R. Slaughter[1] of the Battelle Memorial Institute. He discusses them very briefly under the headings "Porosity," "Embrittlement," "Delayed Brittle Fracture," and "Flakes or Hair-Line Cracks."

The decrease in solubility of hydrogen during the solidification of steel results in the liberation of gaseous hydrogen producing blow-hole porosity and intensifying centre-line unsoundness. In steel ingots porosity due to hydrogen is said to be particularly troublesome in the high-chromium grades. Hydrogen may also be a cause of porosity in steel castings.

A more prevalent defect caused by hydrogen in steel is loss of ductility at moderate or low rates of strain. This is often referred to as hydrogen embrittlement. It may affect all ferritic steels and to a less degree austenitic steels also. One effect associated with this (but not mentioned in the review) is the complete elimination of the yield point in carbon steels which have been cathodically charged with hydrogen.[2] On lowering the temperature, however, the yield point returns and increases in magnitude with decreasing temperature of testing. Hydrogen is unique among alloying elements in that it causes loss of ductility without a corresponding increase in hardness. This loss of ductility, shown by elongation and reduction of area, occurs only at low or moderate rates of strain, and the resistance of the steel in impact tests is not affected. The damage is, however, only temporary. In light sections, hydrogen embrittlement is usually a temporary condition following pickling or electroplating. The steel can be restored to its normal ductility by ageing at raised temperatures to eliminate the hydrogen by diffusion. Thickness and temperature have an important effect. After being cathodically charged with hydrogen a 1in square cast-steel bar was restored to its normal ductility by ageing for six hours at 200 deg. Cent., or sixty days at room temperature, but a 4in square bar, similarly treated, required 100 hours at 200 deg. Cent. or three-and-a-half years at room temperature. These steels, however, were heavily charged with hydrogen. Only in massive wrought sections or castings is it likely that hydrogen retained from the steelmaking operations would cause difficulty with hydrogen embrittlement.

Hydrogen is regarded by E. R. Slaughter as the cause, or a contributory cause, of a defect associated with high-tensile steels and referred to as delayed brittle fracture or static fatigue. When steel parts, heat treated to a tensile strength of more than 80 tons per square inch, have been employed, brittle failures have sometimes been encountered at static loads far below the yield point after delay periods of several months, though specimens taken from the neighbourhood of the fractures showed normal mechanical properties. Slaughter has obtained typical delayed brittle fracture in unnotched high-strength specimens, which had been cathodically charged with hydrogen, at stresses of less than 10 per cent of the ultimate tensile strength. He expresses the view that for failures of this type to occur the presence of hydrogen is necessary, and that hydrogen from pickling or plating operations is the most likely cause of these delayed brittle fractures.

HAIR-LINE CRACKS

The most important defect attributable, at least in part, to hydrogen in steel is the formation of hair-line cracks, for which the presence of hydrogen is a necessary condition, coupled with thermal and transformation stresses. The damage done to the steel is permanent and the consequences may be very serious. Reference is made to the failure of a large low-pressure turbine spindle forging of normalised and tempered nickel-chromium-molybdenum steel, which burst suddenly and without warning.[3] Macro-examination indicated that the main body (which was 83in in diameter, 52in long, with integral shaft about 9ft long) contained about 5000 cracks, not identified by ultrasonic testing, and these were the primary cause of failure. The steel was not in the best condition to resist spread of the cracks. Some reduction in ductility might be expected at the centre of a heavy mass, but in this case the reduction was considered to be excessive. The transition temperature from tough to brittle fracture in notched-bar tests was above the working temperature.

The occurrence of some recent accidents with large forgings (one of which was the example quoted above) has been described by E. E. Thum.[4] Two at least of these forgings contained hair-line cracks. Commenting on Mr. Thum's report, Dr. E. Houdremont[5] stated that in Germany they had attacked the problem of hair-line cracks in various ways: by careful preparation of the furnace charge to minimise its moisture content, by rigid control of the refining period, and by adjustment of the forging and heat-treatment cycles according to the size of the piece and composition of the steel. Finally, he mentioned the new system of vacuum pouring recently perfected at Bochumer Verein, which sucks off enough hydrogen to save ingots which otherwise might turn out to be flaky. So far as possible the composition should be that of a steel which transforms readily on slow cooling and at a high temperature into a pearlitic microstructure. He would avoid steels containing more than 3 per cent of nickel or 0·35 per cent of molybdenum because they transformed mainly in the bainitic, if not partly in the martensitic range, and this was not the best for a hydrogen-relieving anneal.

The necessity of applying a carefully designed heat-treatment cycle to suit each composition and type of forging was emphasised by Dr. H. H. Burton in his presidential address to the Iron and Steel Institute, coupled with the warning that the precautionary treatment could be rendered ineffective by not allowing adequate time for slow cooling through the transformation range. The time factor has also evidently been a difficulty in Germany. Dr. Houdremont went on to state that sometimes the steelmaker was so pressed for delivery that he found it difficult to allow the proper heat treatment, especially the very slow cooling to room temperature. For this reason German manufacturers of large forgings had adopted a policy of holding rough-forged ingots in stock and forging the final shape to order.

The occurrence in America of accidents to large forgings, such as those recently described, has led a group of investigators connected with the manufacture of large forgings and power-generating machinery to publish an outline of the work they are carrying out under the auspices of the American Society for Testing Materials, with the object of finding the causes and cure of brittle fracture in large forgings and establishing methods whereby potentially dangerous forgings may be identified.[6]

REFERENCES

[1] *Journal of Metals*, April, 1956, page 430.
[2] *Acta Metallurgica*, 1955, page 200; 1956, page 114.
[3] See also *Journal of Metals*, March, 1956, page 317.
[4] *Metal Progress*, February, 1956, page 49.
[5] *Ibid.*, March, 1956, page 93.
[6] *Ibid.*, April, 1956, page 63.

Bessemer Centenary

A LARGE part of the June issue of the *Journal of Metals* is concerned with the celebration of the Bessemer Centenary arranged by the American Institute of Mining and Metallurgical Engineers' Bessemer Steel Committee which, by the way, is now to be renamed the "Pneumatic Converter Committee" in view of the expansion in the scope of the pneumatic processes.

The beginnings of the Bessemer process are recounted by A. B. Wilder who also deals with its history during the last hundred years. Early types of converter in England, Sweden and America are illustrated, the introduction of the basic converter is referred to and developments from 1890 onwards are described. Since the earliest designs of Bessemer the size and shape of the converter have changed to meet varying ideas of steelmakers. The detachable bottom was a significant innovation, large tuyere areas were found necessary, side-blowing techniques have been tried repeatedly since the earliest days and opinion still varies as to the best size and shape of the converter and the best location and design of the tuyeres.

The nitrogen factor has had a fundamental influence on the development of the converter process; it was recognised by F. W. Harbord as early as 1896. It has taken years to evaluate the influence of nitrogen in steel, but its behaviour is now well understood and methods have been developed for controlling the amount and behaviour of nitrogen in converter steel. The control of nitrogen by top blowing or surface blowing with oxygen enriched air, bottom blowing with oxygen-steam and oxygen-carbon dioxide mixtures, the use of ore in the HPN process in Germany and of scale in the LNP process at Corby are briefly touched upon in Mr. Wilder's review.

A more detailed account of the various processes in use for the production of low nitrogen and phosphorus converter steels is given in a paper by P. Coheur and H. Kosmider. With these processes it is possible to produce steel of the quality of open-hearth steel, but local conditions will determine which of the various methods can be used to best advantage. Sir Henry Bessemer recognised the possibility of using oxygen in the converter but in his day the cost was prohibitive. In recent years the large scale production of low-cost oxygen has made possible its widespread use in the steelmaking industry and the results are likely to give a new impulse to the basic pneumatic process.

For more than 75 years attention has been directed to the control of the Bessemer blow. Recently an extensive study has been made of converter instrumentation by P. J. Leroy and his co-workers, and a paper follows by P. J. Leroy describing instruments developed in connection with the production of basic Bessemer steel on the Continent. The same instruments are referred to as in the paper by Leroy, Galey and Cawley read at the recent meeting of the Iron and Steel Institute.

In summing up the present position Mr. Wilder recognises that the new blowing techniques for the basic converter have been a commercial success with high phosphorus iron, but states that the present large capacity for open-hearth steel in the United States and the United Kingdom will provide a basis for the widely continued use of the open-hearth process particularly with variations of raw materials and in conjunction with oxygen lance techniques. In connection with the use of the oxygen lance, Coheur and Kosmider put in a reminder that Bessemer did not restrict himself to a study of iron refining in a converter, but also considered refining in a reverberatory furnace. Actually, such processes involving injection of oxygen into open-hearth furnaces ought to be named after their inventor, Bessemer.

Sulphur Embrittlement of Cobalt

RECENT demands for pure metallic cobalt in connection with the preparation of cobalt-rich alloys has directed attention to the effect of impurities on the metal. D. L. Martin* has investigated the embrittlement of metallic cobalt by sulphur, an effect which has hitherto not been of importance as the use of cobalt has been confined to alloys containing less than 75 per cent of cobalt and usually some manganese. As is well-known, sulphur has a detrimental effect on the malleability of nickel owing to the formation of a grain-boundary constituent rich

* *Journal of Metals*, May, 1956, page 578.

in nickel sulphide. This is probably the eutectic of nickel sulphide and nickel containing 21 per cent of sulphur and melting at 650 deg. Cent. The effect of sulphur on cobalt is similar. It forms a eutectic with cobalt sulphide containing 26·5 per cent of sulphur and melting at 879 deg. Cent.

In the investigation carried out by Martin, fifteen specimens of metallic cobalt were prepared from electrolytic cobalt to which sulphide had been added to give sulphur contents of from 0·004 to 0·07 per cent. Two more specimens contained 0·16 and 0·20 per cent of sulphur. As a test for hot shortness these were heated to 1000 deg. Cent. and swaged in air. All specimens with less than 0·008 per cent of sulphur were successfully swaged to ¼in diameter bars : all with 0·015 per cent or more developed intercrystalline cracks. A more severe test was the hot tensile test carried out at 900 deg. Cent. In such tests cobalt containing 0·005 per cent of sulphur or less showed consistently high reductions of area, of the order of 80 per cent, but with increase in sulphur the reduction of area fell rapidly to under 10 per cent with 0·010 per cent of sulphur, and continued to fall with higher sulphur content.

As with nickel, the addition of magnesium is a preventive of sulphur embrittlement. It is of interest to note that T. Fleitmann, as long ago as 1879, found that magnesium additions made cobalt, as well as nickel, malleable. It seems probable that manganese and possibly other metallic additions would be effective in reducing the sulphur embrittlement of cobalt.

Surface Blisters on Steel

BLISTERS on the surface of sheet or strip steel are defects which sometimes accompany pickling operations. They are associated with the occlusion of hydrogen during pickling. The origin of the blisters is considered by F. de Kazinczy, in a paper on the "Formation of Blisters in Iron."* He examined the effect of electrolytically charging discs of Armco iron which had been subjected to two distinct preliminary treatments : (1) annealing at 700 deg. Cent. for forty hours in moist hydrogen to reduce the carbon content while leaving oxygen, sulphur and inclusions unaffected ; and (2) annealing at 1350 deg. Cent. for forty-eight hours in dry hydrogen in the presence of a mixture of mild steel turnings and about 5 per cent of aluminium to reduce slag inclusions and remove oxygen and sulphur. The samples, originally 2mm thick, were then cold rolled to 1mm, normalised, cold rolled to 0·55mm and annealed in a vacuum at temperatures between 250 and 650 deg. Cent. for forty minutes. Two kinds of cracks could be distinguished in the discs that had been charged with hydrogen : (1) cracks originating in the grain boundaries and of a more or less intercrystalline character ; and (2) transcrystalline cracks initiated at inclusions. No completely transcrystalline cracks were observed after the slag inclusions had been reduced in the second treatment and if the cracks were entirely intercrystalline no blisters appeared on the surface. From measurements of the permeability values and equilibrium pressures of the hydrogen it was found that the critical hydrogen pressure required to produce cracks depended on the strength of the matrix and the strain-hardening effects produced by cold work. The character of the crack was governed by the relative strength of grain boundary and matrix. The hydrogen pressure for initiation of cracks at the grain boundaries was lower in the oxygen-rich iron, possibly in consequence of intergranular brittleness. Transcrystalline cracks, observed in specimens which had received the first treatment but not in those in which inclusions had been reduced, were found to originate at the inclusions. This was in accordance with observations made by P. Bardenheuer and G. Thanheiser many years ago.

The flow of hydrogen in these experiments was greater than could possibly be obtained by pickling in acid, but in this operation also cracks underlying blisters are mainly transcrystalline. Pickling blisters are formed only when the continuity of the metal is interrupted by defects or non-metallic inclusions. For example, hydrogen generated in the pickling operation penetrates to imperfectly welded sub-surface blow-holes, where it forms molecular hydrogen under pressure and lifts the surface, causing a blister to form. For this reason rimming steel generally developes more pickling blisters than killed steel. According to de Kazinczy's findings, the higher oxygen content of rimming steel may also have an effect in making these steels susceptible to blisters at a lower hydrogen pressure. The influence of segregation and of non-metallic inclusions may often be shown by a longitudinal pattern of blisters related to the direction of rolling.

Although the formation of blisters is dependent on the presence of certain characteristics of the steel, it is also contingent on a considerable intake of hydrogen. In commercial pickling properly chosen inhibitors or restrainers will decrease the penetration of hydrogen into the steel, and so reduce the tendency to form blisters and minimise other detrimental effects of hydrogen on the steel.

* *Jernkontorets Annaler*, 1956, Vol. 140, page 347.

Surface Effects in Fatigue

ALTERNATING bend tests (at 3000 alternations per minute) on three normalised carbon steels and one heat-treated nickel-chromium steel are described by G. Lissner* in a paper on "The Importance of Surface Effect on the Initiation of Fatigue Cracks." Particulars of the steels are given in Table I. The tests applied were as follows :—

TABLE I—*Particulars of Steels Used*

	Composition, per cent					Treatment, deg. Cent.	Approximate tensile strength, tons/sq in
	C	Si	Mn	Ni	Cr		
A	0·10	Tr.	0·57	—	—	900 air	25·5
B	0·48	0·24	0·33	—	—	830 air	40
C	0·27	Tr.	0·60	—	—	900 air	36
D	0·46	0·30	0·51	2·83	0·74	850 oil, 500 oil	82

(1) The average endurance of a number of electrolytically polished fatigue test specimens was determined at certain applied loads.

(2) At certain selected loads, specimens were subjected to half the number of alternations causing fracture under (1), then aged for twenty-four hours at 100 deg. Cent. and the remaining endurance determined.

(3) At the same selected loads, specimens were subjected to half the number of alternations causing fracture under (1), then turned down by 0·1mm, electrolytically polished with the removal of a further 10μ, and the remaining endurance determined.

Results are briefly summarised in Table II.

TABLE II—*Average Results of Endurance Tests in Thousands of Alternations*

	Steel A	Steel B	Steel C	Steel D
Alternating load applied : Kilogrammes per square millimetre	26	27·5	33	58
Tons per square inch... ...	16·5	17·5	21·0	36·8
Number of alternations to fracture	354	371	328	226
Alternations when test was interrupted	177	186	168	116
Remaining endurance after 24 hours at 100 deg. Cent.	276	246	251	117
Increase per cent over test direct to fracture	28	16	27	3
Alternations when test was interrupted	177	186	168	116
Remaining endurance after turning and electrolytic polishing	223	355	284	322
Increase per cent over test direct to fracture	17	46	37	92

In all cases an increase in endurance was observed after removal of the original surface of the test pieces. In the carbon steels ageing at 100 deg. Cent. had a considerable effect, and ageing during the interval between tests in series (3) must to a considerable extent have contributed to the remaining endurance after turning down and electrolytic polishing. On the other hand, the highest increase in endurance was obtained with the nickel-chromium steel which showed no ageing, and the next highest in the steel B, which showed least ageing among the carbon steels. Individual results showed considerable scatter, but not sufficient to throw doubt on the indications of the average values.

It may be recalled that Dr. N. Thompson,† in a communication to the Royal Aeronautical Society, had found it possible to demonstrate the presence of incipient fatigue cracks in electropolished fatigue test specimens of copper before 50 per cent of their normal fatigue life had expired. They appeared in intense slip bands. Only a few developed into unmistakable cracks before the largest of them had led to complete failure. These marks, which he called "persistent slip bands," were still visible after an electrolytic polishing treatment which eliminated most of the slip bands, but they were removed by electrolytic polishing to a depth of 10 to 20μ. Such polishing was repeated nine times at intervals equal to 25 per cent of the normal fatigue life and the specimen still showed no sign of early failure ; but annealing in a vacuum at 600 deg. Cent. at intervals during the test had no significant effect on the fatigue life or on the appearance of the slip bands.

The results obtained by Lissner show that electrolytic polishing to remove the surface layer gave a similar increase in the fatigue life of steel ; but his results were further held to support the theory that fatigue mechanism involves not only a certain plastic deformation, but also chemical reactions between the oxygen of the air and atoms in the surface zone of the metal. This theory, recently discussed by S. Schaub and W. Liedtke,‡ is based on the long recognised "Russell effect," whereby freshly disturbed metal surfaces in contact with air containing water vapour induce the formation of traces of hydrogen peroxide with accompanying oxidation of atoms of the metal. Whatever the chemical mechanism may be, it was shown many years ago, by Haigh and Brinley Jones in the case of lead and later by Gough and Sopwith for many other metals, including steel, that endurance in fatigue tests can be increased by preventing access of oxygen to the surface of the specimen during tests.

The experiments of Lissner on steel, as well as the earlier tests of Thompson on copper, appear to show that the progressive deleterious effect of oxygen in fatigue tests can be halted by intermittent removal of the surface layer of the test piece.

* *Jernkontorets Annaler*, 1956, Vol. 140, page 360.

Metal Transfer between Palladium and Silver Contacts at Low Inductances (Ref. U/T133). By J. Riddlestone, B.A. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 12s. 6d., postage 4d.—The work reported in Refs. U/T125 and U/T130 has been continued here with palladium and silver contacts. This report gives results for transfer between contacts of these metals breaking a 6V circuit carrying currents between 3A and 15A with inductance in the range of 0·07 to 96μH. Curves are given for the mean cathode gain and the growth of pip steepness for the two metals. The results are compared with those for platinum under similar conditions and it is inferred that transfer between metal contacts is generally the resultant of the superposition of four types of transfer, namely, "residual transfer," "reversed short arc transfer," "short arc transfer," and "long arc transfer." For platinum, with the range of currents and inductances used, it is possible to observe the effect of all four types; for palladium "residual transfer" is not apparent and for silver only the "short arc" and "long arc" transfers are apparent. If the circuit inductance could be reduced to very small values palladium and silver might show the complete range of transfer.

Some theoretical explanation is given of the possible reasons for dissimilarity between the transfer for silver on the one hand and palladium and platinum on the other. Consideration is given to practical applications and it is shown that, in cases where it is desired to minimise the effect of transfer, platinum and palladium are much superior to silver as contact metals if the circuit conditions are chosen correctly.

† *Engineering*, December 3, 1954, page 720.

‡ *Zeitschrift für Metallkunde*, 1953, Vol. 44, page 570.

LETTERS AND LITERATURE

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

OIL TEST LABORATORY

SIR,—I was pleased to see in the July 13th issue your excellent factual report on the Inspectorate of Fighting Vehicles Oil Test Laboratory at Pinehurst, Farnborough, Hants, and on the other activities at the Test House. There are, however, three points of detail concerning the mechanical testing of oils on which I would like to comment.

Regarding the "green" hypoid gears, they are not, in fact, ground, after being cut they are mated and lapped together in pairs; once mated, they are, of course, never separated. The oil which failed in five and a quarter minutes on our high torque rig was S.A.E. 90 hypoid base oil—that is, an untreated base stock lubricant. The S.A.E. 90 gear oil which is available commercially is, of course, treated. The high-speed oil test consists of ten definite cycles as stated, the performance of the gears with different surface treatments should, however, have read "10, 30 and 60 cycles," respectively, not "tests."

The I.F.V. Oil Test Laboratory has been set up as an independent laboratory to test mechanically lubricants for the land services of N.A.T.O. countries.

P. W. HARRISON, A.M.I.Mech.E.,
O. i/c Oil Test Laboratory,
Inspectorate of Fighting Vehicles.

Farnborough,
July 23rd.

Literature

Nouvelle Conception de la Résistance des Matériaux. By A. COUARD. Le Genie Civil, 5, Rue Jules Lefebvre (IXe), Paris, 1e. Price 800 francs.

THIS booklet is based on articles by Monsieur Coüard, previously published in *Le Genie Civil*, and is described as "A Synthesis of the Mechanics of Soils and Solids." It is largely theoretical, but contains particulars of the experimental verification of derived formulæ, and shows how the new ideas developed by Monsieur Coüard can be applied to reinforced and prestressed concrete.

The author points out that he studied the behaviour of materials under test only at the moment of fracture and ignored earlier conditions. He was struck by the fact that the location and slope of cracks in concrete beams, under test, did not conform with traditional theory, and quotes Habib's experiments which, in certain circumstances, cast doubt on the validity of Mohr's graphical analysis of triaxial shear tests. It is generally accepted that in the case of sand the angle of internal friction increases with an increase in compacted density, but Habib's tests showed that with increased pressures, which might reasonably be expected to increase compaction, the angle of internal friction actually decreased when torsion was applied in addition to vertical pressure. Further experiments, in which increasing torsional stresses were applied under constant hydrostatic pressure, revealed that the volume of the enclosed specimen increased steadily. Monsieur Coüard proceeds to discuss two established theories which fail to explain the discrepancies between the results of experimental tests and the behaviour which the materials under test should theoretically follow. One is based on the idea of isostatic lines and the other on Poisson's ratio. He points out that the former cannot be used to explain the characteristics of the cracks in concrete beams under vertical loading and quotes Paduart's opinion that the traditional theory of elasticity cannot be applied to a non-homogeneous material, such as reinforced concrete.

Monsieur Coüard expresses the view that Poisson's ratio is not a definite mechanical property of a material, but is simply an index of the extent of intergranular voids, variable according to the imposed conditions, and unpredictable. The volumetric changes during compression tests are considered, from which it is deduced that solids may be classified in two categories: those in which compaction is not complete, in an absolute sense, such as concrete, and those so perfectly compacted that further volumetric reduction is impossible. In the second group Poisson's ratio may be 0·5 or more, since under compression their volume can only remain constant by lateral expansion. The first category includes compressible materials, in which the initial loading compacts the molecules at the expense of the voids, without lateral dilatation, and Poisson's ratio is zero. Monsieur Coüard pursues this argument a stage further by pointing out that the relative movement of the molecules involves friction and part of the applied energy is lost in heat. The phenomenon is thus irreversible and therefore beyond the range of elasticity.

The traditional elastic theory, continues the author, is only valid in the absence of internal friction. Between the elastic region and the point of fracture the material is in a plastic state, the degree of plasticity depending upon intermolecular adhesion. The reasoning that the angle of internal friction is zero within the elastic limit is extended to the deduction that Poisson's ratio must also be zero up to the same point. It is admitted, however, that this statement may not always hold good, since it is possible to envisage a framework of identical molecules in which axial and lateral deformations can occur without relative displacements among the molecules themselves, and, equally, a partially compacted framework of unequal molecules, for which Poisson's ratio is zero, but in which deformation would involve internal friction.

The familiar mathematical analysis is given of the stresses induced on an oblique plane in a material by two compressions at right angles to one another, and a basic formula is deduced connecting the compressive stresses, the "intergranular adhesion," the angle of internal friction, and the angle of slope of the plane. Further expressions are derived later which apply to various conditions, and, when appropriate numerical factors are inserted, these derived formulæ are shown to give answers which correlate with the results of practical tests. Agreement is found, for example, with Habib's experiments on soils and with Bresler and Wollack's experiments on concrete subjected to compression and torsion, carried out at Berkeley, California.

Monsieur Coüard introduces the somewhat difficult conception of a negative value of internal friction and gives a mathematical explanation which appears to satisfy experimental results. Further evidence in support of his formulæ is provided by a comparison of the derived theoretical data and the actual test results of some American experiments on concrete beams loaded at mid-span. A particularly interesting chapter deals, in part, with the effects of tension, with and without shear, on cylindrical specimens of clay. Habib is quoted as having determined experimentally that the angle of friction of dry clay, grain on grain, is 30 deg., a result confirmed theoretically in the case of clay subjected to combined compression and torsion. A suggested (and logical) explanation is that the contained water is eliminated from the plane of rupture and direct contact of the soil grains then occurs.

Monsieur Coüard has produced a thought-provoking series of articles, conveniently collected into one slim volume, and they will repay careful study, even if, at times, his arguments are not immediately grasped or accepted. His correlation of theory and experiment is certainly impressive. An English translation would be helpful to many British engineers concerned with concrete design or soil mechanics.

Basic Mathematics for Science and Engineering. By PAUL G. ANDRES, HUGH J. MISER and HAIM REINGOLD. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 54s.

Basic Mathematics for Engineers, by the same authors, was first published in 1944. The text of this earlier volume has been revised, and its scope extended with a corresponding addition to the title to show that it is designed to meet the needs of science as well as engineering. There are a number of books dealing with advanced mathematics or higher mathematics for engineering and science. It is usual for the basic mathematics required for both these subjects to be contained in a number of elementary textbooks, each dealing with a separate subject—such as algebra, geometry and trigonometry—and giving the basic elements as a groundwork for advancement in pure mathematics. It is out of the ordinary to find a book specifically and exclusively devoted to the requirements of science and engineering.

To underline the practical nature of the book the first chapter is entitled "Numerical Computations." It includes a description of the slide rule and a discussion on numerical accuracy and scientific notation. The next thirteen chapters, comprising the bulk of the book—492 out of a total of 829 pages—are devoted to algebra and trigonometry. The algebra starts at the beginning with simple manipulations. Again to bring out practical applications the algebraic expressions are not confined to x, y and z, but embrace the symbols and use the formulæ that are to be found in the various branches of science and engineering. The usual topics of elementary algebra are covered—binomial expansion, exponentials, logarithms, simultaneous and quadratic equations. There are, however, some notable omissions. There is no mention of arithmetic and geometric progressions; the binomial expansion is restricted to positive integral indices. On the other hand, determinants and their use for the solution of simultaneous equations

are included. A method of solving linear equations, the "Doolittle method," is described. This systematises the numerical calculations and introduces checks at all stages of the computation. The method is named after the American mathematician Doolittle and not because it is a method for reducing the numerical work to a minimum—although such is the case.

Trigonometry similarly starts from first principles with a description of the various functions, including their graphical representation. The standard identities are then considered with practical applications to alternating current problems and to the solution of triangles. Again there are some omissions. No mention is made of the formulæ involving the trigonometrical functions of half-angles and the sides and semi-perimeter of a triangle. The various forms of representation of complex numbers, their conversion from one form to another, their manipulation and their application to alternating current circuits, are well treated.

There are four chapters on co-ordinate geometry. The first three cover from the beginning the straight line, the circle and the conic sections; the last deals with solid analytic geometry. The penultimate chapter covers the elements of differential calculus. It is confined to the differentiation of simple algebraic and trigonometrical functions with applications to elementary mechanics problems and finding maxima and minima. The last chapter deals in the same introductory manner with integral calculus. There is an appendix which summarises the fundamentals of elementary geometry and tabulates formulæ for surface areas and volumes. To conclude there are thirty-two pages of mathematical tables.

A particular feature of the book is the large number of exercises which follow every section of the work. To a large extent engineering and scientific terminology and symbols have been introduced and practical problems demanding a slide rule answer have been set. At the end of the book are collected the answers to all the odd-numbered exercises. Providing answers only to half the exercises may itself at first sight appear odd. On reflection, however, it is considered to be a good idea. It is explained in the preface that the book has been written so that it can be used for home study. When doing exercises without supervision there is a great temptation to look at the back of the book before completing a particular problem and, knowing the answer, contrive to get the correct solution. It is far better training to do some exercises where the answer is not given, to check the working, to acquire a sense that the answer is of the right order, and to have confidence that the solution is correct. The book is, in fact, very suitable for home study. Throughout complete and very clear explanations are given and worked examples in great detail have been introduced at all stages. Helpful features are the introductory discussions at the beginning of each chapter and the progress reports which constitute a summary at the end.

This is a well written and well produced book. It will be apparent, however, from the description of the contents that it does not go far enough to meet the requirements of the engineer—or the scientist—in basic mathematics. It does not cover the syllabus in a number of the examinations that have to be taken in the first stages of engineering and science. Nevertheless the ground that is covered is done so with great thoroughness. It can be recommended for the student with little previous knowledge who wishes to acquire a sound groundwork of the basic mathematics that is used in science and engineering.

Examples in Mechanical Vibrations. By J. HANNAH and R. C. STEPHENS. Edward Arnold (Publishers), Ltd., 41, Maddox Street, London, W.1. Price 18s.

THIS little book is intended entirely for those cramming for examinations. It consists mainly of worked examination questions and numerous unworked questions for which the answers are given. It has been pointed out in the preface that other textbooks on theory of machines and vibrations must be consulted for a thorough and fundamental understanding of the subject. It is thought necessary to stress this again here, for the few pages of so-called "derivation of the formulæ" given at the start of each chapter are quite inadequate to give a grasp of the significance of vibration theory and are, in fact, in some instances misleading.

The object of a teaching course in an engineering subject should be the development of an ability for clear thinking and the application of fundamental concepts to practical problems, not merely an ability for filling in formulæ. The aim of this book would appear to be diverted to the latter. Much of this could have been avoided by including some general remarks on the aims of examination questions and on the correct approach to them. More explanation of why a particular formulæ is to be used for the solution of a problem, and a derivation of such a formula from first principles, would have been of more value than the details of arithmetic computations. Little has been said about the important question of units and the gravitational constant.

The examination questions are taken from the Universities of London and Glasgow, and from the Institution of Mechanical Engineers. It is not stated over which period of years these were set. This is to be regretted as the curricula of some of the courses may have been changed.

"*Schiffstechnik*," *Forschungshefte für Schiffbau und Schiffsmaschinenbau.* Hamburg: Schiffahrtsverlag "Hansa" C. Schroedter and Co., Hamburg, 11, Stubbenhuk, 10. Price DM.6 (double issues DM.10·50), for subscribers DM.5 (double issues DM.8·50).

THE "*Forschungshefte*," now in their fourth year, are published in collaboration with seven German shipbuilding colleges and research stations, the German Association of Naval Architects (Schiffbautechnische Gesellschaft e.V.), and the Technical Committee of the Shipbuilding and Ship Propulsion of the Sea Transport Commission (Technischer Ausschuss für Schiffbau und Schiffsmaschinenbau des Seeverkehrsbeirats). In size and make-up similar to the well-known V.D.I.-Zeitschrift, "Schiffahrtstechnik" contains articles on problems connected with all aspects of naval architecture from the point of view of design as well as that of fundamental research.

Zur Interpretation von seismischen Refraktionsmessungen. By MAX WEBER. Mitteilungen aus dem Institut für Geophysik, No. 28. Zürich: Eidgenössische Technische Hochschule, Institut für Geophysik, Leonhardtstrasse 33, Zürich, 6.

THIS number of the Mitteilungen contains Dr. Weber's three articles, "The Interpretation of Seismic Refraction Measurements," "Determination by Means of Seismic Reflexion Measurements of an Interface of Any Degree of Curvature," and "The Time-Distance Surface of a Wavefront Undergoing Multiple Reflexion in an inhomogeneous Body with Any Amount of Surface Curvature." In the first article, a simple method is developed, based on the recorded travel-time curve, for calculating the frontal velocity as a function of the depth, on the assumption that it is a monotonically increasing function of the depth. The second article shows how an interface with arbitrary curvature can be calculated from seismic reflexion measurements along a measuring surface of any curvature, under the assumption that the measuring surface and the interface together form a smooth closed surface and that the enclosed material is homogeneous and isotropic. Lastly, Dr. Weber discusses the problem of calculating the travel-time surface for multiple-reflexions in a perfectly elastic body in which the wave velocity is a stepwise continuous function of the depth, and which has a surface of any curvature.

DIN Bezugsquellen für Normgerechte Erzeugnisse (*DIN Buyer's Guide*). By W. PORSTMANN. Second revised edition. Deutscher Normenausschuss (DNA), Berlin, W.15, Uhlandstrasse 175. Price DM. 7. Obtainable from British Standards Institution, 2, Park Street, London, W.1.

THE *DIN Buyer's Guide*, which was first published in 1950, contains in the present edition nearly 2000 suppliers of standardised components. Approximately 30,000 entries for standard components of all classes have been included, and in many branches the lists can be claimed to be complete. The book is arranged in two parts, a numerical index according to the numbers of the DIN-standards, and an alphabetical index of suppliers' names and addresses.

Total Heat/Entropy Chart for Steam. By WRIGHT-BAKER (Callendar). Edward Arnold, Ltd., 41, Maddox Street, London, W.1. Price 1s.

A CHART rather less than 15in square has been drawn for steam up to temperatures of about 1000 deg. Fah.: this should be particularly convenient for the student, who will not require or be able to spread out the more ambitious charts. Tables of specific volume and of liquid heat at saturation temperature are added for the pressure range 0·2–1000 lb per square inch covered by the curves.

Books Received

The World's Tankers. By Laurence Dunn. Adlard Coles, Ltd., 7, Brunswick Place, Southampton. Price 35s.

High Temperature Technology. By I. E. Campbell. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 120s.

Einführung in die Mikrowellenphysik. By Gerhard Klages. Verlag Von Dr. Dietrich Steinkopff Darmstadt. Price DM.31.

Differential Equations. Third edition. By Harry W. Reddick and Donald E. Kibbey. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 36s.

Thermal Power from Nuclear Reactors. By A. Stanley Thompson and Oliver E. Rodgers. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 58s.

Analytical Experimental Physics. Second edition. By M. Ference, H. B. Lemon and R. J. Stephenson. Cambridge University Press, Bentley House, 200, Euston Road, London, N.W.1. Price 60s.

Industrial Electricity: Vol. I, *Direct Currents.* Third edition. By Chester L. Dawes. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 41s. 6d.

Carrington Power Station

An ultimate capacity of 480MW is envisaged at Carrington Power Station where the existing station, with four 60MW hydrogen-cooled generating sets can be duplicated by a second 240MW station in the future. Steam for the four sets is raised in seven p.f.-fired boilers generating 360,000 lb of steam per hour at 940 lb per square inch and 920 deg. Fah. Circulating water is taken from the Manchester Ship Canal. The station output is transmitted in bulk from 132kV and 275kV substations which adjoin the station and are equipped with air blast circuit breakers. In the 275kV substation four overhead line circuits will be connected to the supergrid. Two of these four 275kV overhead lines link Carrington and Drakelow and are already in commission.

CARRINGTON power station, which was officially opened by Alderman Sir William Walker on Friday, July 20th, is built on a site bounded on the north by the River Mersey and on the west by the Manchester Ship Canal. It is a new station, designed for an ultimate capacity of 480MW, half of which has already been realised in the "A" station, while the remaining 240MW will be developed in the future to form the "B" station.

Although the site was acquired in 1916, as an alternative to the Barton power station site, it was not exploited until after the second world war, when the present station was planned by the Manchester Corporation Electricity Department. Work was started late in 1947 and on April 1, 1948, the project, together with the rest of the Corporation's electricity, was vested in the British Electricity Authority. The station is now in the North West, Merseyside and North Wales Division of the Central Electricity Authority. The divisional controller is Mr. A. R. Cooper, the chief generation engineer (construction) is Mr. C. R. Watson-Smyth, and the station superintendent is Mr. J. R. Appleton.

Because of the variable load bearing capacity of the site all major structures are carried on reinforced concrete piles cast *in-situ*. Beam and slab construction spanning the pile caps is used for the r.c. foundation rafts. The main station buildings (Fig. 1) are steel framed and brick clad. All the main items of auxiliary plant, including pulverising mills, i.d. and f.d. fans, boiler feed pumps, steam receivers, conservator, and blowdown tanks are installed at basement floor level, 43ft above O.D. The main operating floor of the turbine station is 26ft above basement level and all the floors are of reinforced concrete cast *in-situ* with the exception of the boiler galleries, which are of steel open grid flooring. A loading bay with rail access is provided transversely across the station between Nos. 2 and 3 sets.

Coal is normally supplied by rail. Three side-discharge wagon tipplers, with Avery weighbridges, supply coal direct to the bunkers via a belt conveyor system with a capacity of 400 tons per hour. The coal store has a capacity of 206,000 tons and is stocked by means of two side-discharge tipplers with Avery weighbridges. Coal is recovered from the store by bulldozing to a reclamation hopper at the end of the belt conveyor or by bulldozing up ramps into wagons. Tramp iron is removed from the coal by a 48in diameter magnetic head drum, made by Electromagnets Ltd., suspended over No. 1 conveyor belt. Two British Jeffrey Diamond "Flextooth" crushers, each with a capacity of 200 tons per hour, driven by a 100 h.p. motor, reduce the coal to a 90–95½ product passing a 1in square mesh grid.

Boilers

Of the seven boilers in the station, Nos. 1 to 4 were supplied by Babcock and Wilcox, Ltd., and Nos. 5 to 7 by John Brown Land Boilers, Ltd. The three John Brown boilers were the first to be designed and built by this company for the Central Electricity Authority. Automatic equipment is provided to control the fuel supply, steam pressure, combustion air and furnace pressure of each boiler. On all boilers the main dampers are remotely controlled by Lockheed hydraulic mechanism operated from the boiler control panels and the boiler auxiliary motors are also started and stopped from these panels.

Each boiler is a high-head, single-drum, natural-circulation, radiant-heat, p.f.-fired installation designed to raise 360,000 lb of steam per hour at 940 lb per square inch and 920 deg. Fah. The design is based on the combustion of coal having a volatile content of 17 to 34 per cent, an ash content of 6 to 25 per cent, and a calorific value of 10,000 to 12,500 B.Th.U. per pound. The drum is slung from overhead steelwork, all expansion is downwards.

Referring to the Babcock and Wilcox boilers, forty "Cyclone" centrifugal separators are provided inside the drum. The furnace is water cooled, the major part consisting of bare tubes, with Bailey blocks in certain sections, including part of the furnace rear wall and the rear wall of the furnace hopper. Pulverising is by four "E-50" mills per boiler, and the fuel is burned in eight triple-port horizontal, inter-tube boilers. Each boiler has four automatic retractable oil burners, with electric ignition and pressure atomisation for lighting-up purposes. Two 20-ton oil tanks, Hamworthy pressure and transfer pumping units and a 60kW heating element are provided. The superheater is of the multi-loop design in two sections, with inter-stage attemperators of the surface type, two per boiler, for temperature control. A certain amount of control is also possible by gas by-passing. The economiser is of the continuous loop design, arranged in three banks. Dampers are provided for partial by-passing of the economiser when necessary. Babcock and Wilcox tubular air heaters are installed, in two banks, the primary arranged for three-pass air flow and the secondary for single-pass air flow. Each boiler has fifteen sootblowers, nine being of the retractable, single-nozzle design, hydraulically operated, and six of the mass-element design. They are automatically sequence-controlled by Babcock-Lockheed gear to operate through the full sequence, or with pre-selected suppression of any individual blowers, or for the individual operation of any particular blower. During sequence operation, if any head fails to complete its operation in a predetermined time, operation is stopped automatically, and an alarm is sounded. Each pair of boilers is provided with an instrument panel containing, in addition to sootblower control equipment, instruments and controls for mills, boiler fans, automatic combustion control, oil firing and damper control.

Bailey automatic combustion control is provided. Copes' automatic feed water regulators, "Igema" remote water level indicators, and Hopkinsons' high and low water alarms are fitted.

All the f.d., i.d. and primary air fans are of James Howden manufacture. There are also four Keith Blackman blowers per unit for supplying sealing air.

Some Particulars of Boilers and their Auxiliaries

Babcock and Wilcox

Superheaters.—Multiloop, single steam pass, primary and secondary stages; total heating surface, 16,780 square feet; temperature control, attemperators between stages, and by-pass dampers.

Attemperators.—Two per boiler; total heating surface, 920 square feet; steam temperature, 920 deg. Fah., maintained (±10 deg. Fah.) from output of 240,000 lb to 360,000 lb per hour.

Economisers.—Continuous loop, triple bank; total heating surface, 17,790 square feet.

Air Heaters.—Tubular two-stage, with internal gas flow; total heating surface, 92,000 square feet.

Forced Draught Fans.—Two per boiler, backward bladed, single inlet; maximum capacity per fan, 59,600 cubic feet per minute at 100 deg. Fah.

Induced Draught Fans.—Two per boiler, radial tipped, double inlet; maximum capacity per fan, 98,300 cubic feet per minute at 280 deg. Fah.

Primary Air Fans.—Four per boiler, backward blades, single inlet; maximum capacity per fan, 15,000 cubic feet per minute at 550 deg. Fah.

John Brown Land Boilers

Superheaters.—"Melesco," single steam pass, primary and secondary stages; total heating surface, 21,120 square feet; temperature control, tubular desuperheater between stages.

Desuperheaters.—Two per boiler; total heating surface, 300 square feet; steam temperature, 920 deg. Fah. maintained (±15 deg. Fah.) from output of 288,000 lb to 360,000 lb per hour.

Economisers.—Two Greens' "Premier Diamond Type 8" units in parallel per boiler; total heating surface, 22,744 square feet.

Air Heaters.—Two per boiler, Ljungstrom rotary; total heating surface, 100,800 square feet.

Forced Draught Fans.—Two per boiler, backward bladed, single inlet; maximum capacity per fan, 64,000 cubic feet per minute at 90 deg. Fah.

Induced Draught Fans.—Two per boiler, backward bladed, double inlet; maximum capacity per fan, 100,500 cubic feet per minute at 280 deg. Fah.

Primary Air Fans.—Four per boiler, backward bladed, single inlet; maximum capacity per fan, 15,000 cubic feet per minute at 550 deg. Fah.

On the three John Brown boilers the economisers were made by E. Green and Son, Ltd., and the air heaters by James Howden and Co., Ltd.

Variable-speed commutator motors drive the i.d. and f.d. fans and constant-speed motors the primary air and seal air fans. The variable-speed motors are "N-S" motors made by Laurence Scott and Electromotors Ltd. They are equipped

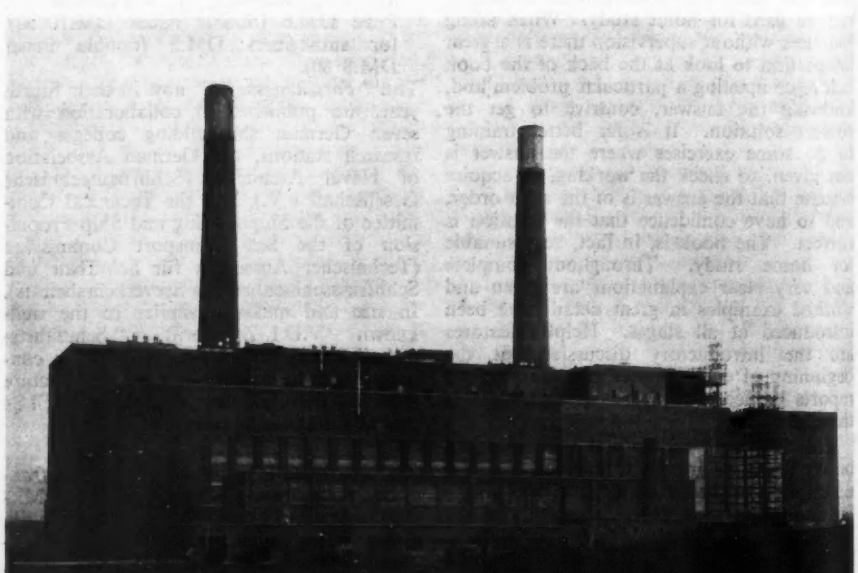


Fig. 1—Carrington power station as seen from the west. It has an installed capacity of four 60MW turbo-alternators and seven p.f. fired boilers each generating 360,000 lb of steam per hour at 940 lb per square inch and 920 deg. Fah.

Fig. 2—Four hydrogen-cooled sets installed between 1953 and April 1956 in Carrington power station. Nos. 1 and 2 sets have three-cylinder turbines, and Nos. 3 and 4 sets have two-cylinder turbines, with double flow l.p. cylinders in each case

with induction regulators actuated by the Bailey electro-pneumatic control system.

Ash and Dust Handling Plant

Each boiler has one water filled "A"-type ash hopper. At intervals the ash is fed by high-pressure water jets which discharge the ash through one of duplicate crushers into a sump where further water is added as necessary. The ash-water mixture is pumped by one of two "Hydroseal" ash pumps with two-speed motors to one of three settling pits. Sealing water to the ash pumps is provided from the high-pressure pumps through a Royles strainer. Pressure-operated mercury switches trip the "Hydroseal" pumps should the sealing water supply fail.

The sluicing water is provided by one of two Mather and Platt "Medivane" pumps situated in the riverside pump house. One of two additional pumps supplies cooling water for the ash hoppers, and fan bearings and the make-up to the ash sump. All four pumps draw water from the river.

Before being discharged into the main flues and chimneys the flue gases from the boilers pass through two-stage, horizontal-flow Lodge Cottrell electrostatic precipitators having a guaranteed efficiency of 97·5 per cent at M.C.R. The dust collected in the air heater and electrostatic precipitator hoppers is drawn intermittently from them by feeder ejectors which discharge the dust-water mixture through separate dust sluiceways into the ash sump, where it is collected by an ash pump and discharged to the settling ponds. The dust in the chimney hoppers is drawn through windswept valves via a "Hydrovactor" into the dust sluiceway.

Turbo-Alternators

The four turbo-alternators (Fig. 2) in "A" station are 60MW, 3000 r.p.m., hydrogen-cooled Metropolitan-Vickers sets. Nos. 1 and 2 sets are driven by three-cylinder turbines and Nos. 3 and 4 by two-cylinder turbines; all four are impulse turbines, with double-flow l.p. cylinders. The stop-valve steam conditions are 900 lb per square inch, 900 deg. Fah.; vacuum 28·6in Hg; back pressure 1·4in Hg. Feed heating is in five stages, giving final feed temperatures of 380 deg. Fah. in Nos. 1 and 2 sets and 385 deg. Fah. in Nos. 3 and 4 sets. Each of the twin-shell annular-flow condensers (Fig. 3) has a cooling surface of 60,000 square feet and is designed to pass 3,000,000 gallons of cooling water per hour with an inlet temperature of 70 deg. Fah.

The a.c. generators are each rated at 75MVA, three-phase 50 c/s, 11·8kV and are hydrogen cooled. They have welded steel stator frames, roughly circular in cross section, with four coolers arranged longitudinally in the space between the outer periphery of the stator yoke and the core. Hydrogen at a pressure of ½lb per square inch is used in the machines and is circulated by means of propeller fans mounted at each end of the rotor. The hot gas is directed by a system of ducts over the water-cooled tubes of the coolers before re-circulating through the machines. The bearings are carried in the end shields, and thrust-face oil seals prevent the escape of hydrogen along the shaft. The seal assemblies are mounted inboard of the bearings, and can be dismantled without disturbing the end shields. Excitation is obtained from direct-connected main exciters, which are in turn excited by pilot exciters having their armatures overhung from the main exciter shafts. The automatic voltage regulators for the generators are Metropolitan-Vickers "VS6" equipments, and are mounted on the voltage regulator panels in the control room.

One of the five panels constituting the turbine gauge board contains "turbovisory" instruments for indicating and recording differential axial movement and eccentricity between the turbine rotors and cylinders—the h.p. and i.p. stages in the case of Nos. 1 and 2 sets and the h.p. stages in the case of Nos. 3 and 4 sets.

Circulating Water and Feed Water

Cooling water for the four sets is taken from the Manchester Ship Canal, the c.w. intake pump house being to the south-west of the station. The water passes through rough bar screens and four rotary drum screens and is circulated to the station by eight horizontal-spindle 21,600 g.p.m. pumps through two 78in diameter steel pipelines supported on piles. From the condensers the water flows by gravity through two r.c. ducts, 8ft 3in by 6ft 6in, and over a side-discharge weir into the ship canal. Before inlet to the condensers the water is dosed with chlorine to prevent the accumulation of slime. Each of the two chlorinators has a capacity of 6000 lb per twenty four hours and is arranged for automatic eight-point intermittent injection under the control of a master programme clock.

Make-up feed water is taken from the town mains to two base-exchange water softening plants, each capable of treating 6300 gallons per hour (from a hardness of 2·94 parts $CaCO_3$ per 100,000 to zero hardness after treatment) and producing about 150,000 gallons between regenerations.

For each turbo-alternator there is a live-steam triple-effect evaporator (Nos. 1 and 2 being made by Aiton and Co., Ltd., and Nos. 3 and 4 by Metropolitan-Vickers Electrical Company, Ltd.) with a capacity of 25,000 lb per hour. With each pair of generating sets there are four boiler feed pumps—three motor-driven and one turbo-driven, each having a capacity of 600,000 lb per hour.

132kV Substation

Each generator is solidly connected to the 132kV system through a 75MVA, 11·8/132kV generator transformer with OFB. cooling and on-load tap changing by remote hand control. The main 132kV substation, which is sited immediately to the east of the main power station building, is equipped with duplicate busbars and air-blast switchgear for the connection of the four generator transformers, two station transformers and thirteen feeder circuits (including four to the 275kV substation nearby) one bus section and two bus couplers. These 132kV circuits are provided with M-V "GA6S" air-blast circuit breakers having two series interrupter heads per phase, rated at 3500MVA, isolating switches, busbar selector and earthing switches, line coupling equipment for h.f. injection, circuit marshalling kiosks, and a compressor building.

Each line equipment includes a by-pass isolator allowing the circuit breaker to be serviced with the line on load. Correct operation of these isolators is ensured by an electrical bolt interlock system which also enables all circuits to be transferred on-load between the main or reserve busbars as required. The generator transformers and station transformers are installed on the 132kV substation site.

275kV Substation

About ¼ mile further east is the 275kV substation (Fig. 4) where the initial installation

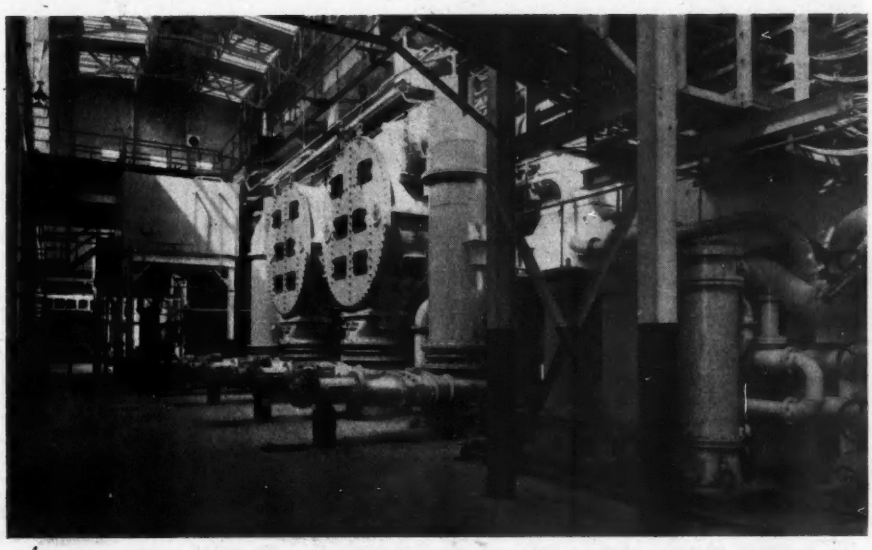


Fig. 3—Basement showing twin condensers with motorised valves. The steam receiver in the boiler-house basement also has motorised valves with alternative handwheel operation

provides for a double-busbar layout with seven air-blast circuit breakers controlling four overhead line circuits and four 275/132kV transformers (Fig. 5). Eventually the station will be the main centre of interconnection between the 275kV super-grid and the heavily loaded areas of Manchester, North Cheshire and South Lancashire. At present, however, only two of the 275kV overhead lines (those from Drakelow) are being commissioned, together with two only of the circuit breakers—those controlling the four 275/132kV auto-transformers which are banked in pairs on the h.v. side, each pair being fed directly from one of the lines.

The main 275kV switchgear consists of M-V "GA10W8" air-blast circuit breakers, each having eight series interrupter heads per phase, with a rating of 12,000A and a breaking capacity of 7500MVA. Sufficient self-contained compressed air storage is provided on the circuit breaker for two closing and opening operations to be completed in the event of complete failure of the central compressed-air supply. The fault clearance time of the circuit breakers, measured from closure of the tripping contacts, is stated to be 0·06 second (3 cycles) including arcing time.

Off-load switching is carried out on English Electric isolators which, because of their size, are operated by oil pressure from a motor-driven pump. Those isolators which may require immediate operation in an emergency can be remotely operated from the control room. For example, if a fault should occur on one of the transformers in a banked pair, the appropriate isolator can be opened and the other transformer can be switched in again—the whole operation being done from the control room. Inadvertent operation of the isolators under load is prevented by electrical bolt interlocks, and safety during maintenance, with correct operation of earthing switches' is ensured by Castell key interlocks.

The circuit-breaker air receivers are kept charged with air at 325 lb per square inch from compression and reducing plant housed next to the 275kV relay room. There are four compressors each capable of compressing 30 cubic feet of free air per minute to a pressure of 600 lb per square inch in three stages. Air is stored in two groups of six air receivers at this pressure, and is passed through a reducing valve dropping the pressure down to 325 lb per square inch. Each group of six receivers holds the equivalent of 3264 cubic feet of free air, sufficient for ten closing and opening operations on a circuit breaker in addition to the two such operating cycles accounted for by the local receivers on the breaker.

There are four 275/132kV transformers, each having a maximum continuous rating of 120MVA. They are wound as star/star auto-transformers with a tertiary delta winding. Forced cooling is by two radiator banks with oil pumps and with six cooling fans, three per bank. Buchholz protectors are mounted in the oil pipes between the main tanks and the conservator tanks, which are above the radiator banks. Overall circulating current protective gear is provided on the transformers by means of an "FV2" instantaneous relay in the 275kV relay room operating from balanced current transformers adjacent to the 275kV and 132kV circuit breakers and in the neutral point. Buchholz and winding temperature tripping devices are also fitted. A tank earth indicator, operated from a current transformer connected between the tank and the substation earth bar, enables the faulty transformer of a banked pair to be identified. The transformers have on-load tap changing operated remotely from the control room.

Fig. 5—Four 120MVA 275/132kV auto-transformers in Carrington 275kV substation. The on-load tap changing mechanism is in separate compartments under the 132kV terminal bushings and is remotely operated from the control room

The protective gear for the 275kV lines and transformers is housed in a relay room on the 275kV site. All the overhead lines have Metropolitan-Vickers "Contraphase" electronic phase-comparison unit-type protection. This system requires a high-tension supply for the valves which is obtained via power packs from an a.c. motor-generator installed in the relay room. The motor generator is a.c. driven and has a flywheel to maintain its output during momentary loss of a.c. supply such as occurs during system faults. A sustained failure of the a.c. automatically brings into operation a standby d.c. equipment.

Station Auxiliary Supplies

Each turbo alternator and boiler is operated, on the electrical side, on the unit principle the supplies for normal running being derived from unit transformers connected directly to the associated alternator. Supplies for station auxiliaries, emergency and starting-up requirements are taken from two 10MVA transformers installed outdoors in the 132kV substation.

The consultants for the civil engineering and building work were Messrs. C. S. Allott and Son, and the external treatment of the station was the responsibility of Mr. L. C. Howitt, F.R.I.B.A., City Architect of Manchester.

The main contractors and principal sub-contractors were as follows :—

Civil Engineering and Building Works.—Site excavation, earthworks, roads and drainage, Taylor Woodrow Construction, Ltd.; reinforced concrete piles, Simplex Concrete Piles, Ltd., John Gill Contractors, Ltd.; foundations (section "A"), foundations (ancillary buildings), reinforced concrete work in 132kV, reinforced concrete work in c.w. system, A. Monk and Co., Ltd.; sewage disposal, Ames Crosta Mills and Co., Ltd.; superstructure (section "A"), W. and J. R. Watson, Ltd.; ancillary buildings, W. and J. R. Watson, Ltd.; foundations (section "B"), superstructure (section "B"), M. J. Gleeson (Contractors), Ltd.; structural steelwork, Sir William Arrol and Co., Ltd.; precipitators, Bierrum and Partners, Ltd.; brick chimneys, P. C. Richardson and Co. (Middlesbrough), Ltd.

Mechanical Plant.—Boilers Nos. 1–4, Babcock and Wilcox, Ltd.; boilers Nos. 5–7, John Brown Land Boilers, Ltd.; ash and dust handling plant, Babcock and Wilcox, Ltd.; coal handling plant, W. and J. Jenkins and Co., Ltd.; turbo-alternator sets, condensing and feed heating plants, Metropolitan-Vickers Electrical Company, Ltd.; motor-driven feed pumps, Mather and Platt, Ltd.; turbine-driven feed pumps, G. and J. Weir, Ltd.; h.p. and l.p. pipework, Stewarts and Lloyds, Ltd.; valves, Hopkinsons, Ltd.; circulating water pipes, Danks of Netherton, T. B. Pearson and Sons, Ltd.; circulating water pumps, Mather and Platt, Ltd.; circulating water screening plant, valves and penstocks, J. Blakeborough and Sons, Ltd.; motor-driven cup type screen, F. W. Brackett and Co., Ltd.; chlorination plant, Wallace and Tiernan, Ltd.; 130-ton turbine house crane, Clyde Crane and Booth, Ltd.

Electrical Plant.—Main 132kV switchgear, Metropolitan-Vickers Electrical Company, Ltd.; generator and station transformers, Ferranti, Ltd.; auxiliary switchgear, English Electric Company, Ltd.; cabling, British Insulated Callender's Cables, Ltd.; supervisory control gear, Automatic Telephone and Electrical Company, Ltd.; 132kV cables, W. T. Glover and Co., Ltd.; reactors, Hackbridge and Hewittic Electric Company, Ltd.

275kV *Substation.*—Civil engineering work, Sir A. McAlpine and Son, Ltd.; main switchgear and supergrid transformers, Metropolitan-Vickers Electrical Company, Ltd.; isolating and earthing switches, English Electric Company, Ltd.

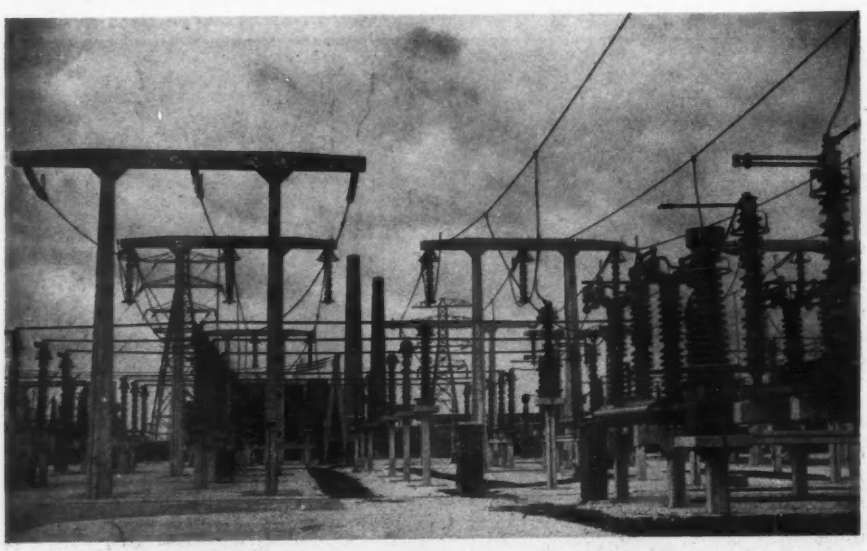


Fig. 4—275kV substation adjoining Carrington power station. Four 275/132kV transformers banked in pairs are connected through isolators and air-blast circuit breakers to two overhead line circuits to Drakelow. Later Carrington will cater for four such circuits in the 275kV super-grid

Measurement of Cutting Tool Performance with Radioactive Isotopes

A LABORATORY in which radioactive cutting tools are used for research into tool life, cutting fluids and machinability, has been established by Alexander Duckham and Co., Ltd., of Hammersmith, London, W.6. The principle of the tests is to make the cutting tool radioactive; then as the cutting tool wears, radioactivity is transferred to the turnings and the cutting coolant. Measurement of the amount of radioactivity thus transferred has a direct relationship with the wear on the cutting tool. The main advantages of using radioactive cutting tools for work of this kind are that accurate and repeatable results can be obtained with a minimum of machining time and metal consumption.

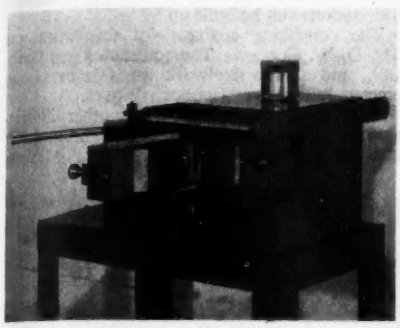
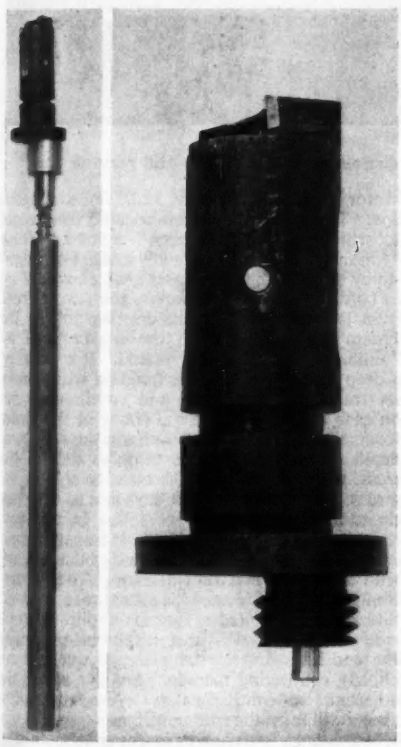


Fig. 1—Lead store chamber for radioactive tool tips



Figs. 2 and 3—(Left) Extension handle fitted to tool holder. (Right) Tool holder detail

In choosing suitable materials for cutting tools for these wear tests use was made of earlier work which had established that selected tungsten carbides, when irradiated in a nuclear reactor, gave tracer radio isotopes Cobalt 60 and tungsten 185 with sufficient half life and energy to be suitable for use in cutting tool studies.

For experimental work "Wimet X.8" tungsten carbide was chosen. This has the following chemical composition: tungsten carbide, 77 per cent; cobalt, 8 per cent; titanium carbide, 15 per cent. This material, when subjected to neutron bombardment in a nuclear reactor for approximately one week, gave tracer radioactive isotopes of cobalt 60 and tungsten 185 which were satisfactory for the initial test studies.

The half life and kind of radiation from this cutting tool is:

Radio isotope	Half life	Type of radiation
Cobalt 60	5·2 years	Beta and gamma
Tungsten 185	73 days	Beta

The "Wimet X.8" tungsten carbide tipped tools were sent to Harwell, where they were irradiated to an approximate total activity of beta and gamma radiation of 15 millicuries per gramme of the tool tip (1 curie $= 3{\cdot}7 \times 10^{10}$ disintegrations per second or 40,000 million disintegrations per second). The approximate split of the 15 millicuries per gramme of tool tip is 10 millicuries of beta radiation and 5 millicuries of gamma radiation per gramme of tool tip. For the purposes of tool wear studies, gamma radiations only are used because beta radiations possess only slight penetration powers and poor recording properties due to chip piling. On the other hand, gamma rays have good penetrating powers, consisting of high-energy rays of short wavelength and good recording properties; they penetrate considerable thicknesses of metal. A cutting tool so activated is estimated to give some eighty minutes of cutting time per tool edge. Cutting tests of six to ten seconds' duration have proved to yield sufficient wear products to give gamma radiation counts on the scintillator of three to five counts per minute. Hence, some 500 tests can be run off once the machine has been set up.

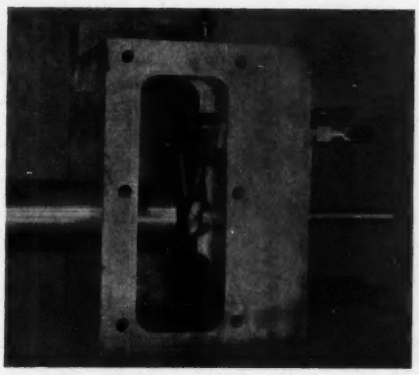


Fig. 4—Interior of cutting chamber with cover removed to show coolant jets

Although the activity level of 15 millicuries per gramme is not high, strict precautions are taken against radiation hazards.

The section of the mechanical test laboratory radioactive tests is constructed of metal and glass partitioning with plastic covered benches and floors which are impervious and readily cleaned and can be quickly decontaminated. Protective clothing and shoes are worn by everybody working in this laboratory. A decontamination zone must be traversed by all personnel before leaving the danger area. Each operator is supplied with a personal dosemeter. A log is kept of the amount of exposure of each operator so that at all times the maximum permissible dosage rate of 0·3 roentgens per week is not exceeded. In addition, the operators are medically examined at five-weekly periods. All radioactive cutting tools are stored in a lead chamber (Fig. 1), which has a central rotary mandrel holding four tool tips. The chamber has been specially machined so that a tool holder with an extension handle (Figs. 2 and 3) can be inserted from a safe distance and a spring release cam operated to engage a tool tip.

The method of test consists of measuring the radioactivity of the chips resulting from the cutting operation involving the use of radioactive cutting tools. It has been established that 95 per cent of the tool wear products are always embedded in the chips. Small amounts of the radioactive tool wear products are to be found in the cutting coolant and on the machined workpieces, but for preliminary experiments and comparisons measurement of the radioactivity of the chips alone is considered a true measure of cutting tool wear.

The tools used for the test are small tool bits approximately ¼in square by $^{9}/_{32}$in thick and weighing approximately 15 grammes. Each is finished-ground to shape and marked for identification. On completion of the tests on the two cutting edges of the tool tip it is returned to Harwell for disposal.

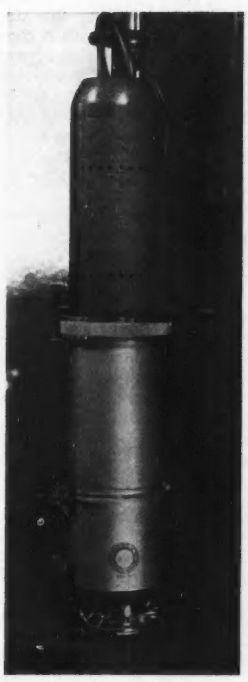


Fig. 5—Scintillation counter head with beaker containing radioactive chips

The cutting operation is done on a Swift "8V.3" lathe, which has a spindle speed of 20 to 1500 r.p.m. powered by a 15 h.p. motor. In the initial experiments investigation is confined to the use of tubular steel of 60-ton tensile chrome-molybdenum in the annealed condition. The cut is taken at right angles to the circular axis of the tube, the tubular workpiece being held in the chuck of the lathe and the whole surrounded by a specially designed cutting chamber (Fig. 4). The choice of tube as a workpiece eliminates surface condition troubles and gives a constant cutting speed in feet per minute.

The cutting chamber is of steel, 1in thick, mounted on the bed of the lathe, and it is completely enclosed to protect the operator from radiation. It has been designed for easy access and cleaning; it is polished and contains its own cutting fluid circulating system, which supplies cutting fluid from two jets, one on either side of the cutting tool. The cutting fluid drains into the base of the chamber, is collected in a reservoir and then recirculated over the workpiece and cutting tool. In the base of the cutting chamber is a small perforated container, in which all the cutting turnings are collected.

Machine setting for speed and feed can be varied according to the kind of study being made. Speeds varying from 200ft to 800ft per

minute are possible with feeds from 0·003in up to 0·15in per cut. Cutting proceeds for about ten seconds until approximately 1¾ oz or 50 grammes of chips are produced. It has been found that this is sufficient metal to give adequate radioactive count.

After cutting operation, the chips, in their perforated tray, are taken from the cutting chamber, placed in an aluminium or stainless steel tray, taken to the measuring laboratory and washed. Water and methylated spirits are the washing agent when a soluble oil coolant has been used and solvent naphtha when using a neat oil coolant. The chips are dried and weighed and exposed to the scintillation counter (Fig. 5) and their radioactivity is recorded as so many pulses per second on a scaling unit, whence the calculated amount of tool wear is expressed as counts per minute per gramme of chips. From this count must be deducted the background radioactivity reading arising from radiation naturally present in the atmosphere and "scatter" from radioactive material in the laboratory.

Normally the test is repeated five or six times and an average of the results is obtained, the results being checked against a standard.

Some Recent Industrial Structures

THREE interesting light industrial structures, each of a rather different nature, are described here. The first is an aluminium dome, forming a roof for a reservoir ; the second is a factory to withstand mining subsidence ; and the third is a bus garage with a clear span of 105ft, built with a steel frame comprising prefabricated tubular elements bolted together.

Roofing Topler's Hill Reservoir.—The aluminium dome covering the Topler's Hill reservoir was built without emptying the reservoir, since no disturbance of the actual impounding structure was necessary. The staging used during construction, which was movable, is clearly shown in the accompanying illustration. The dome is 125ft in diameter and consists structurally of a number of box-section ribs forming two intersecting series of great circles. A number of domes of this kind have been built and they have been proposed for spans of 500ft.* The structure described here was one of two similar domes designed and built for the Biggleswade Water Board by Aluminium Construction, Ltd., the Board's consultants being Messrs. Binnie, Deacon and Gourley.

The dome has a circular ring beam, set in reinforced concrete at bearing shoes with screw adjusters. It is clad with 16 S.W.G. light alloy sheet and weighs 16 tons. The main ribs are made by riveting together two top-hat sections; intersections are made by cutting one of each pair of sections so that half of each rib runs through the joint. Joints between the 20ft lengths of ribs are made by inserting joint filler pieces, also of top-hat section ; all joints are arranged so as to be clear of the intersections. Structural sections are of Noral 51SWP (B.S. 1476 : HE10WP), and the sheets are of Noral M57S½H alloy, supplied by Northern Aluminium Company, Ltd. Painting or other surface protection was considered unnecessary. The two roofs were completed in seven months, using the same staging for both of them.

Factory to Withstand Mining Subsidence.—The second factory to be completed at Peterlee New Town has been built for occupation by Alexandre, Ltd. The main factory building has a floor area of about 40,000 square feet.

Coal workings were started under the site in 1946 and it was predicted that vertical differential subsidence of about 9in could be expected.

The main factory building is thus made up of thirteen units, each 120ft wide by 25ft long. Any of the thirteen units can subside without seriously affecting the building. Each unit is a structural steel frame of all-welded construction, comprising four stanchions, two to each side, and two lattice girders 120ft long. Each pair of stanchions is braced together at points 8ft 4in apart and is hinged at the base. The lattice girders form the sides of the monitor roof lights, and are rigidly connected to the pair of stanchions at one end. The other ends are hinged at the stanchion caps, so that when subsidence occurs, the 25ft wide strip of roof rotates slightly to accommodate the movement of the stanchions. The roof is of steel deck with thermal insulation and is carried on castellated beams running across the bottoms of the girders to cantilever on either side. The girders have a rise of 18in at the centre and the deck beams follow this curve to give drainage slope to the roof deck.

To maintain the structural independence of each unit, the tops of the girders are braced together, while the bottoms are braced with a horizontal girder formed in conjunction with the deck beams. The side cladding is of aluminium with thermal insulation.

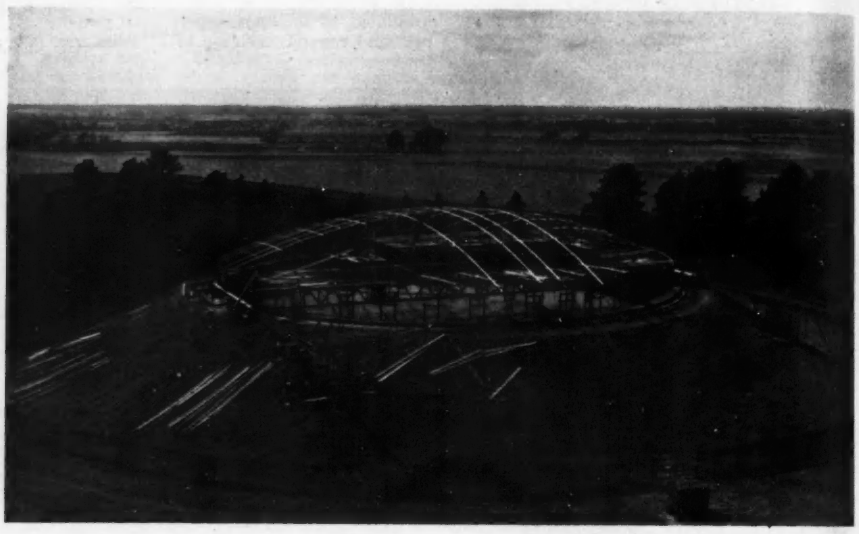
Provision has been made for jacking the stanchions should the settlement approach the predicted figures, and all the anchor bolts have long extensions with sleeves so that the concrete foundations can be built up.

The consulting engineer for this work was Mr. D. W. Cooper. The contractor was Bovis, Ltd., and all the steelwork was fabricated and erected by Palmers Hebburn Works.

105ft Span Bus Garage.—Our other illustration shows the steel frame of a bus garage under construction for the Birmingham and Midland Motor Omnibus Company, Ltd., at Leamington Spa. The steelwork is prefabricated from tubes according to the "Unimer" system. These "Unimer" buildings normally consist of single-storey sheds with roof trusses giving spans of up to 60ft. Above 60ft, however, the normal roof truss becomes unduly cumbersome, and so the system illustrated, which the makers call an "umbrella" roof, is used instead. It consists of a deep girder spanning the building with trusses set transversely across it and cantilevered out on each side. Thus, the top chord of the girder forms the "ridge" of the roof and the structural depth of the girder is the same as that of the truss, which cantilevers 20ft on each side of the girder. The girder has 15ft bays and so can span up to 105ft in multiples of 15ft. In this case there is one 105ft span, and one 45ft span beyond it, and there are four 40ft "bays" to the building with a 105ft by 18ft 4in extension. The illustration gives a good idea of the structural steelwork. Site joints are bolted ; there is additional truss steelwork at the gable end, with wind-bracing in the end bays and in the plane of the bottom chords, connecting the edge cantilevers with the adjacent stiffening girder. Asbestos-cement sheets will form the roof covering.

Advantage is claimed for these tubular steel buildings for various reasons, amongst which are the lightness and cleanness of the tubular design. Further interest is added to this particular building because soil stabilisation has been used in constructing the floor area, and the hard standings and access roads. The soil stabilisation was carried out to a depth of 9in, with a 3in surfacing above it.

The steelwork is being supplied and erected by E. H. Smith (Westhaven), Ltd., and the soil stabilisation is under the direction of the Soil Engineering and Contracting Company, Ltd.



Erection of a domed aluminium roof, 125ft in diameter, over the Topler's Hill reservoir

Prefabricated tubular steel frame for a bus garage. The main girders span 105ft and have "butterfly" trusses cantilevering for 20ft on each side of them

* See discussion by Mr. G. P. Manning on the paper, "The Structural Design of the Dome of Discovery, Festival of Britain, 1951," by G. Roberts. *Journal, I.C.E.*, October, 1951.

Pumping Plant for the Wallasey Impounding Station at Mersey Docks

By J. B. SCIVIER, B.Sc. (Eng.), A.M.I.Mech.E.

An installation of four 54in steam-turbine-driven centrifugal pumps, and their associated plant, is described. The pumps replenish part of the impounded system of docks of the Mersey Docks and Harbour Board. They operate against low heads and are of large capacity.

AN important new pumping station for the impounding of the Wallasey Docks has recently been commissioned by the Mersey Docks and Harbour Board. The new plant replaces an existing installation which was put into operation at the end of the last century and has been in continuous use ever since, and which comprised three "Gwynne" 54in pumps driven by tandem compound vertical engines, each discharging 1200 tons of water per minute.

The new plant comprises four 54in centrifugal pumps driven by steam turbines through reduction gearing. The boiler installation for the new pumping station was existing when it was decided to install new pumping equipment, and consists of four "Thompson" economic boilers. It is intended that two boilers and three main pumps will be at work, thus keeping two boilers and one main pumping set as standby.

Layout of the Station

Fig. 1 shows the interior of the new pumping station, and Fig. 2 a sectional elevation through it, and one set of suction and discharge pipework. Each pump has individual suction and discharge pipelines and the sets are therefore independent of each other. The arrangement of the pipework on this installation is of particular interest, since the pumps are provided with siphons in the discharge pipes instead of valves.

As can be seen from Fig. 2, the siphons are below coping level and are external to the pumping station. The invert of the pipe at the crest of the siphon is 1ft above the highest water level in the dock. Thus, when air is admitted, reverse flow of water through the pump is prevented. The pumps are provided with sluice valves on the suction side for isolation.

A detailed view of one pumping set is shown in Fig. 3, in which the arrangement of the turbine, condenser, reduction gearing and pump may be noted. The condenser circulating pump is driven from the gearbox. In addition to the main pumps, the installation includes two seepage pumps, one of which is electric-motor-driven and the other steam-engine-driven. A 10-ton hand-operated overhead travelling crane is also installed and arranged to traverse the complete length of the pump house.

Performance of Main Pumps

The main pumps draw water from the River Mersey and deliver it to the Wallasey Docks, which are maintained at a constant level of about 22ft above old dock sill datum. Each pump is designed for maximum efficiency when delivering 63,250 gallons per minute against a total head of 24·1ft when running at a speed of 200 r.p.m. Pumping commences with a tide level in the river of 1ft above O.D.S. datum and finishes at the same level, the average rate of pumping under these conditions being 65,000 g.p.m. per pump. The maximum height of spring tides above O.D.S. datum is 21ft.

In addition to the normal design considerations to achieve the required rate of pumping, care had to be taken to ensure that the pumps deliver a sufficient quantity of water to prime the siphons when starting up, even with the tide level in the river as low as 1ft above O.D.S. datum.

It will be appreciated that, when starting, a sufficient velocity of water is required at the crest of the siphon to entrain all the air in the pipe, so that the maximum siphonic efficiency is obtained. The effective static head under this starting condition is the difference between the water level on the suction side and the top of the pipe at the crest of the siphon, and on this particular installation this static head with a tide level of 1ft O.D.S. is approximately 5ft 6in greater than the normal maximum static head when pumping with the siphon fully primed.

Fig. 5 shows the head/volume characteristic of the pumps and the range of operating heads, including the maximum head required to prime the siphon. Although the head, and consequently the rate of pumping, varies with tide level in the river, it is intended that the pumps shall run at constant speed.

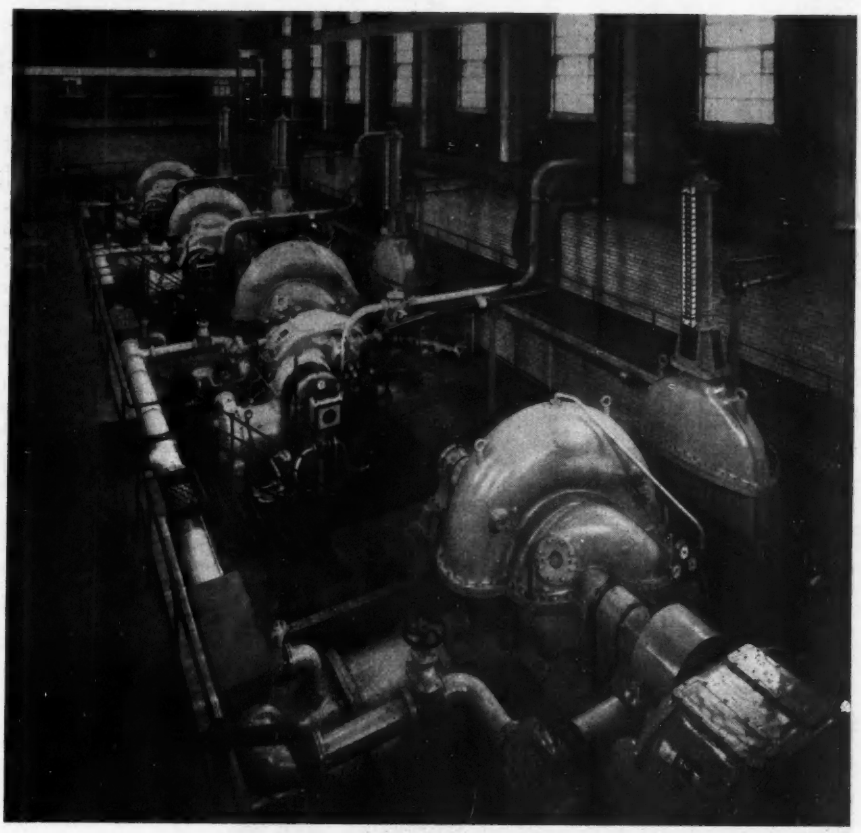


Fig. 1—Interior of pumping station, with four 54in centrifugal pumps driven by steam turbines

Construction of Main Pumps

The four main pumps were manufactured by Gwynnes Pumps, Ltd., and are horizontal double-entry split-casing centrifugal machines, having 54in discharge and 60in suction branches. The sectional arrangement of the pumps is shown in Fig. 5.

Each pump has a high-grade close-grained cast iron casing split on the horizontal centre line with both branches formed in the lower half, thus enabling the top half to be removed for inspection of the impeller and shaft, and also the removal of the rotating parts without disturbing the suction and discharge pipe connections. A renewable cutwater is fitted in the casing, and also large handholes are provided on the top half for inspection of the eye of the impeller without disturbing the casing.

The impeller is of the double entry shrouded type constructed in Admiralty gunmetal and it is carried on a forged steel shaft. Renewable "Barronia" metal rings are fitted to the casing at the points of running clearance with the impeller eye, and similar rings of gunmetal are fitted to the impeller. The shaft has renewable bronze sleeves such that it is entirely enclosed by the impeller boss and sleeves within the casing. Metallic packing in the stuffing boxes was manufactured by the U.S. Metallic Packing Company. The packings are cooled with clean town's water.

The pump journal bearings are roller bearings arranged in cast iron pedestals which are mounted on brackets secured to the lower half casing and also supported on concrete plinths. The tail end pedestal also incorporates a ball thrust bearing to locate the rotating element. Each pump is coupled to the output shaft of its gearbox by a "Wellman Bibby" flexible coupling.

Before starting the main pumps it is necessary to prime them, together with the suction piping. For this purpose a steam ejector is fitted to the highest point of each suction line adjacent to, and on the river side of, the suction isolating valve. The pump casing is filled through a pipe from the dock which by-passes the discharge siphon. The suction pipeline is then primed with the ejector and the pumping set is then ready to start.

Valves

Each pump is provided with a 60in suction isolating valve manufactured by Glenfield and Kennedy, Ltd. The valves are hydraulically-operated sluice valves having body, wedge, dome, cylinder, cylinder stool and cylinder cover of Meehanite cast iron. Gunmetal-faced rings are provided on the wedge and body and the glands and cylinder are also lined with gunmetal.

Each valve is operated by a gunmetal piston provided with leather cups and fitted to a bronze spindle which in turn is attached to the wedge. A bronze tail rod extends through the cylinder cover to operate a pointer on an indicator board showing the position of the valve gate at any time. The control slide valve, which is of gunmetal, is operated by a lever.

The valves are designed for an unbalanced head of 30ft and the working pressure for the cylinder

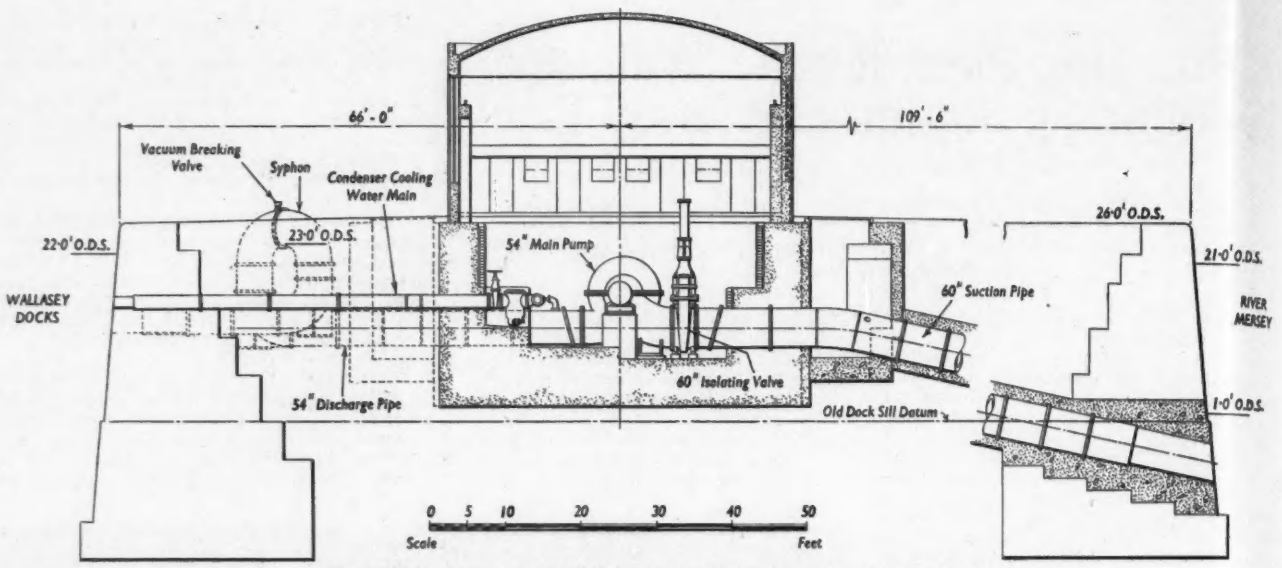


Fig. 2—Section through pumping station for the impounding of the Wallasey Docks

is 750 lb per square inch, the high-pressure water being obtained from the hydraulic mains.

At the crest of each siphon, there is a " Morgan-Gwynne " automatic vacuum breaking valve which prevents the admission of air to the siphon while the pump is working, but breaks the siphon vacuum as soon as the flow of water ceases.

Steam Turbines

Each main pump is driven by a steam turbine, manufactured by Hick, Hargreaves and Co., Ltd. These turbines are rated at 600 b.h.p., 6000 r.p.m., and are straight condensing impulse machines working with a steam pressure at the stop valve of 200 lb per square inch, temperature 588 deg. Fah., and with 28½in vacuum at the turbine exhaust.

The high-pressure end of the turbine casing is of cast steel and the low-pressure end of cast iron. Each turbine is supported on fixed feet at the low-pressure end; at the high-pressure end the bearing block slides on a key in the bedplate, thus maintaining axial alignment at all temperatures.

The bearings are of cast iron lined with white metal and are semi-rigid with short parallel supporting faces. A Michell thrust bearing is incorporated, with special provision for free circulation of oil between the pads.

The rotating element consists of a series of wheels mounted on a shaft constructed in best quality steel thoroughly annealed. The glands are of the carbon ring type and at the high-pressure end the small amount of leakage steam is drawn off to the condenser, while at the low-pressure end a small amount of high pressure steam is supplied in order to " pack " the glands. Flexible couplings are of the " gear " type. The turbine wheels are of high tensile forged steel, mounted on the shaft on steel support rings and with blades milled from stainless steel bar.

The stop valve is of the globe type mounted directly on to the steam chest; a separate emergency valve is incorporated and held open by the action of full oil pressure on the piston. A powerful spring closes the valve when the oil pressure is released, and a dashpot arrangement is incorporated to relieve shock upon the valve seat when closing. A double-beat governor valve is incorporated, together with an additional overload valve. The governor is a two-spring centrifugal device; an emergency governor prevents over-running beyond 10 per cent of normal speed.

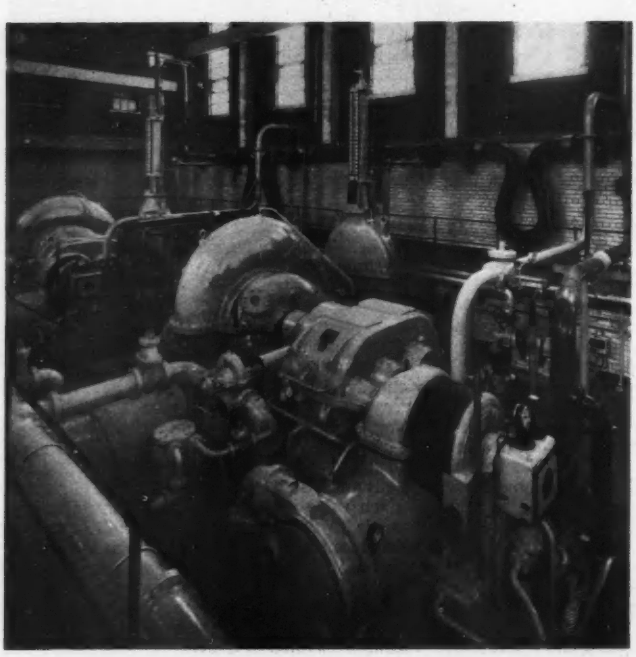
The lubricating system comprises a main oil gear pump driven from the turbine shaft; oil is discharged at a pressure of approximately 40 lb per square inch, at which pressure the supply of oil necessary to actuate the governor is obtained. A steam-driven centrifugal auxiliary oil pump is used when starting and shutting down the turbine. A cooler is incorporated on the pressure side of the system between the distribution box and bearings.

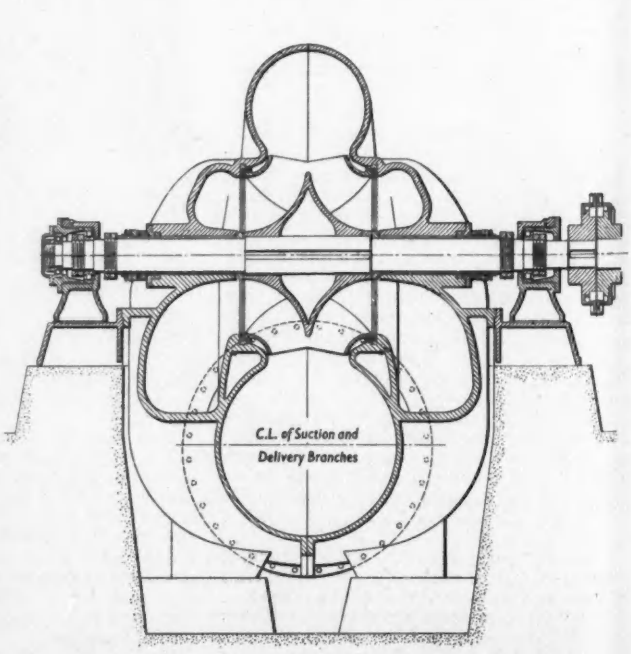
A bedplate is arranged under the turbine exhaust end foot and under the double reduction gears, the whole being mounted on a concrete plinth. Each turbine is equipped with the usual accessories, including a sensitive tachometer, steam and oil pressure gauges and thermometers.

Condensers

The shell of each of the condensers is constructed as part of the bottom half turbine casing. The bottom of the condenser is formed to give a free flow of condensate to the extraction pump. The tube plates are of naval brass, an intermediate support plate preventing the tubes from sagging and preventing vibration. The tubes are of aluminium brass and the ferrules are of solid drawn brass.

An atmospheric exhaust relief valve is arranged with a water seal to prevent air leakage; it is





Figs. 3 and 4—(Left) Main pumping set, illustrating arrangement of turbine, condenser, reduction gearing and pump. (Right) Section of 54in impounding pump

hand operated, with an adjustable dashpot to prevent hammering of the valve on its seat. A "Hivac" condensate extraction pump—a vertical spindle double impeller machine—is provided, driven mechanically from the turbine oil pump spindle at 960 r.p.m.

The condenser circulation water is provided by a "Gwynne" 7in/8in "KL," double-entry

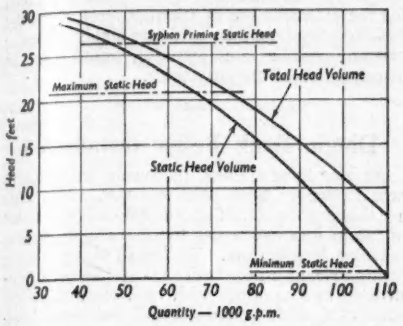


Fig. 5—Head-quantity characteristics of impounding pump

centrifugal pump, having cast iron casing and gunmetal impeller, which is driven from the intermediate shaft of the double reduction gear through a bevel gear. Each condenser circulating pump draws its water from a bus main in the pump house. The water is taken from, and returned to, the dock.

A "Hivac" two-stage surface-cooled air extractor having gunmetal ejector bodies and steel steam head is provided, together with a "Hivac" single-stage ejector for the circulating water system.

This work has been carried out under the direction of Mr. A. B. Porter, engineer-in-chief of the Mersey Docks and Harbour Board.

Technical Reports

Flameproof Electrical Apparatus: Flanged Joints, One Inch in Radial Breadth, in Mixtures of Acetone Vapour and Air (Ref. G/T305). By T. J. A. Brown, B.Sc., A.R.C.Sc., A.Inst.P., and N. Simpson. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 7s. 6d., postage 4d.—For explosive mixtures of acetone vapour and air, ignited in a bronze sphere of 8 litres capacity having horizontal equatorial flanges 1in in radial breadth, the range of most incendive internal mixtures was found to contain from 5 to 6·5 per cent of acetone vapour by volume; in the determination of the maximum safe gap a mixture containing 5·9 per cent was used. The most readily ignitable external mixtures contain from 4 to 6 per cent of acetone vapour by volume, and a mixture containing 4·5 per cent was used in the determination of the safe gap. The maximum experimental safe gap, M.E.S.G., obtained with this combination of internal and external mixtures, on a criterion of $n=20$, $k=0·001$in, was found to be 0·040in; and the statistical maximum safe gap, re-assessed, S.M.S.G.(R) is 0·033in. The experimental and statistical safe gaps obtained with flanges ½in in radial breadth are given in report Ref. G/T274; a comparison of the results given in that report with those now presented shows that as a result of the 50 per cent reduction in flange breadth the M.E.S.G. is reduced by 15 per cent and the S.M.S.G.(R) is reduced by 24 per cent.

Atmospheric Freezing, Pulsations and Evolutionary Progression in the Long-Period Variable Stars (Ref. Z/T100). By C. E. R. Bruce, M.A., D.Sc., M.I.E.E. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 4s. 6d., postage 4d.—It is suggested that electrical charge separation may be caused in stellar atmospheres by the freezing out of different materials, just as the separation of charges in thunderclouds is associated with the freezing of water. The electrical discharges resulting from the charge separation offer an explanation for the pulsations of long-period variable stars and their irregularity, and for the appearance of the bright lines in their spectra. The theory suggests that the evolutionary sequence of these stars is from Types R and N, through S, to Type M, and would explain the change from Type M to Type S shown by χ Cygni and other stars at specially bright maxima. It is also in accord with the hypothesis of "veiling" put forward by Merrill to account for the very low luminosity of the long-period variables at minimum.

Cationic and Nonionic Chemical Plant

A plant to produce the Armour range of cationic and nonionic chemicals has been built at Littleborough at the factory of Hess Products, Ltd. The plants are connected by pipelines and designed to operate automatically on the straight-through principle, with provision for material at each process stage to be diverted for particular industrial purposes.

PLANS to produce the Armour range of cationic and nonionic chemicals in Great Britain have resulted in the construction of new plant which is operated by Hess Products, Ltd., Littleborough, and forms a natural extension to that company's works. The existing plant produces a large range of fatty acids and these are treated in the new plant to produce nitriles, primary, secondary and tertiary aliphatic amines, water soluble amine acetates, and aliphatic diamines, &c., which have wide uses in a large number of industries. Mr. S. R. H. Fletcher, the chairman of Hess Products, Ltd., formally opened the new chemical section at a ceremony which was held on June 19th and was attended by representatives of industry, commerce and research bodies.

The combined plants are contiguous and are linked by pipelines and pumps so that the units, both of which run continuously and are fully automatic, can operate on the straight-through principle. Thus the raw materials enter at one end and the finished product leaves at the other, with provision being made for material at various stages of the process to be used as required for industrial purposes. The various process stages are indicated in the flow line chart which we reproduce.

Raw material, from animal, marine and vegetable sources, undergoes a preliminary cleaning before delivery to a measuring tank, where it is mixed with water before being pumped to an autoclave to which steam is admitted at 350 lb per square inch. Here it is split by steam pressure hydrolysis and blown out to settling tanks, where the liquor settles and from where the crude glycerol liquor is passed to evaporators to recover as much as 90 per cent of the glycerine. Some of the split oil is piped from storage to a Scott straight distillation unit. Here the oil passes through a dryer before entering the distiller, which is heated to 240 deg. Cent. by Dowtherm vapour. The water is evaporated under vacuum and the oil vapour drawn to condensers and a water circulated oil cooler and then to storage. Instead of being distilled, the split oil can be passed, according to demand, direct to the fractional distillation plant, which consists of three columns, and functions on principles approximating oil refinery practice, in that bubblecap trays are fitted and reflux control used to obtain economically the maximum degree of fractionation. Dowtherm liquid heating is employed, the Dowtherm passing through an oil-fired boiler of 1,000,000 B.Th.U. per hour capacity and being circulated by Holden and Brook pumps. Contaminated Dowtherm is distilled for re-use. The fractionating columns are connected in series and produce a number of cuts, since cuts can be taken off at each column, and the last fraction can, if required, be recirculated, leaving pitch as a residue. Steam is used as a stripping agent and the whole unit operates automatically, only one shift operator being required in the control room.

The pure compounds of the fatty acids are

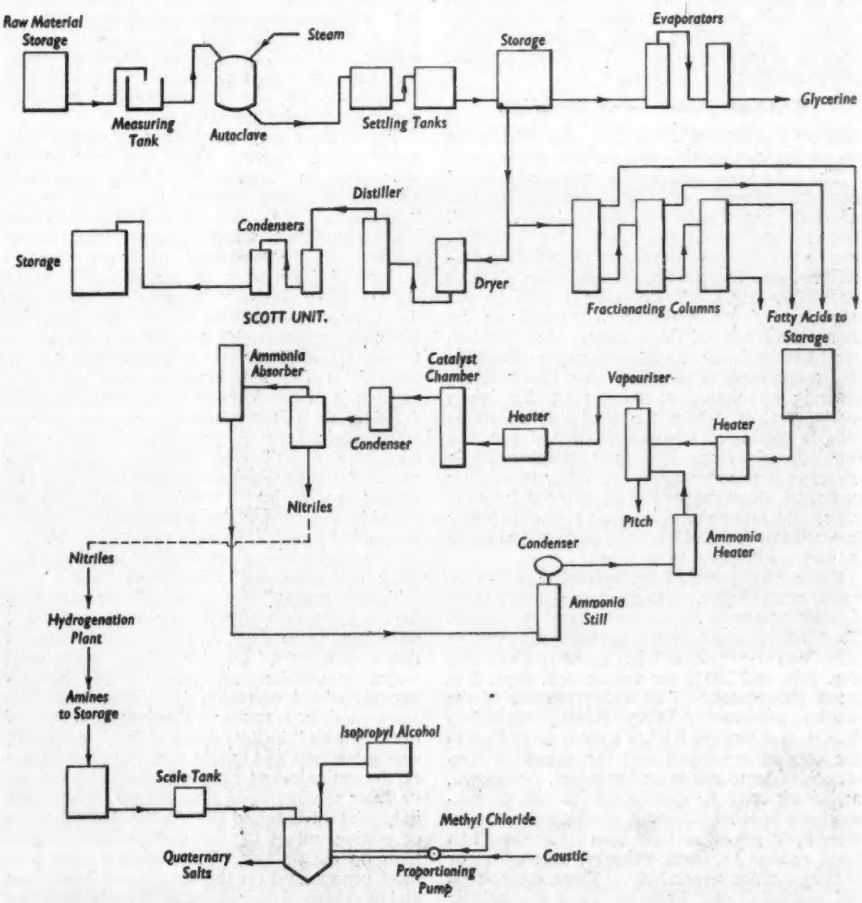


Fig. 1—Flow line diagram showing process stages to produce fatty acids, and cationic and nonionic chemicals

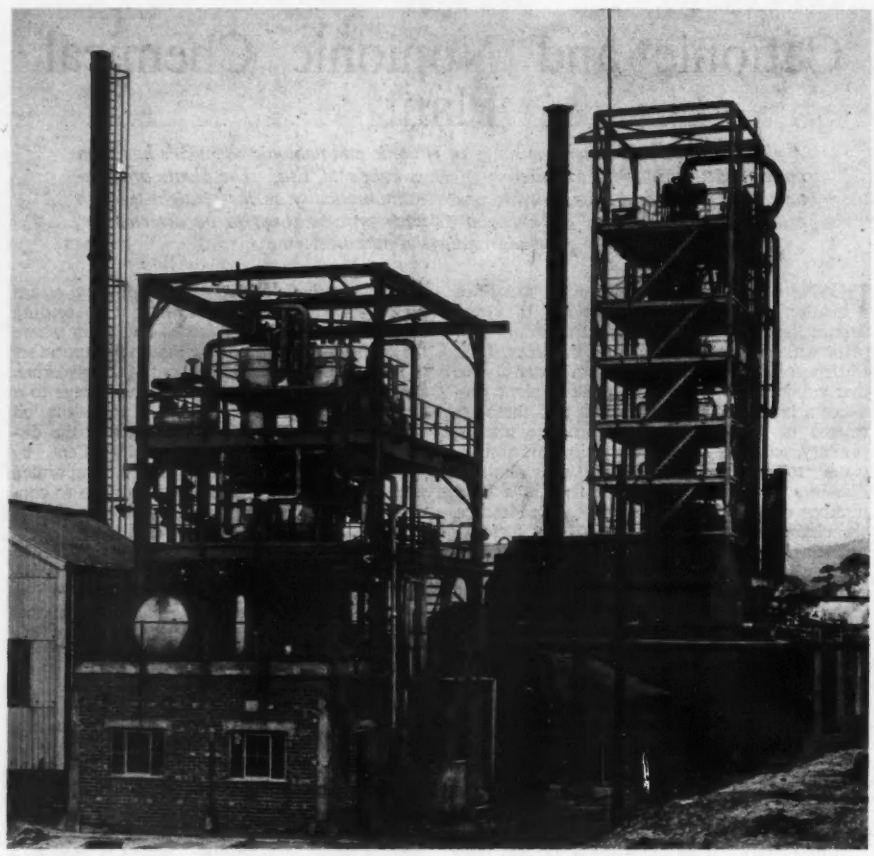


Fig. 2—The nitrile plant is shown in the foreground with the fractionating unit behind

blended according to requirements and are then fed to the nitrile plant, where they come into contact with anhydrous ammonia to produce nitriles in a combined liquid and vapour phase process, as the final product. The overall formula of the reaction can be written

$$R\,COOH + NH_3 \longrightarrow RCN + 2H_2O,$$

where R is a fatty acid radical. Our illustration shows the fractionating unit and the nitrile plant.

The anhydrous ammonia is produced from 25 per cent ammonia, which is stored at a pressure of 80 lb per square inch in a separate still. Heated fatty acids and anhydrous ammonia vapour are fed into a Dowtherm-heated distilla- column, and the reaction, which takes place at about 300 deg. Cent., produces amides by the expulsion of one molecule of water from the ammonium salt of fatty acids. The reaction products consisting of ammonia, amide, fatty acid and water vapours pass through a heater before entering a column, containing an aluminium oxide catalyst, where the final conversion to nitriles is completed by the removal of a second molecule of water. Vapour from the catalytic chamber passes through a condenser to another chamber, where the nitriles are stripped from the water and ammonia. The weak ammonia liquor is piped to a still and later recycled and the crude nitriles are pumped to storage.

Some of the nitriles are marketed under the trade mark Arneel, but most are subjected to further processes to convert them to amines. This is carried out in a catalytic hydrogenation plant and the reaction takes place at about 300 deg. Fah. and 200 lb per square inch, depending upon the process. This hydrogenation of the nitriles produces primary RNH_2, secondary R_2NH, and tertiary $RR^1{}_2N$ amines according to the catalyst employed and the operating conditions of temperature and pressure. As shown, an amine may be considered to be a substituted ammonia molecule, in which one, two or three hydrogen atoms have been replaced with an alkyl radical to form primary, secondary or tertiary amines respectively. These compounds are marketed as "Armeens" and are cationic surface active agents, which are available in a range of chain length and degree of saturation. The primary amines have a wide range of commercial applications, such as pigment grinding, softening and dispersing agents; aids to extrusion lubrication and mould release, in the rubber industry; oil additives; intermediates in the synthesis of wetting agents; corrosion preventatives; and in the ceramics, building, paper and plastics industries.

The amines may be further processed into water soluble forms. These are their acetate salts, sold as "Armacs" or their quaternary ammonium salts, which are marketed as "Arquads." Oil-soluble quaternary salts can also be manufactured in the same plant. Other products are the "Armids," which are nonionic amides of fatty acids of the general formula $R.CO.NH_2$ and the "Duomeens," which are di-amines of the formula $R.NH.C_2H_6NH_2$. The latter are concentrated cationic chemicals containing about 85 per cent of pure amine. "Duomeen T" is of value as an anti-stripping agent and as such is of considerable help in road surface dressing, since it obviates the hazards of rain when roadmaking by preventing stripping and allowing the work to go forward without stoppage. For the production of the "Arquads" the amines are fed into a vessel, to which methyl chloride and caustic are added through a proportioning pump manufactured by E.D.C. Pumps, and where an exothermic reaction takes place in the presence of isopropyl alcohol.

The "Armacs" are principally employed as flotation agents, emulsifiers, wetting agents and solutizers, while the "Arquads" find a use as textile softeners, laundry aids, agricultural toxicant emulsifiers, bactericides and in the production of oil corrosion inhibitors, anti-static agents and foam rubber. The industrial uses of the "Armids" include those of foam stabilisers, wax substitutes and mould release agents. Some of the cationic and nonionic chemicals are oil or water soluble, while most dissolve in common industrial solvents and all have the characteristics of plating out in the form of mono-molecular films on most solids. Their surface activity is most pronounced on the solid/liquid interphase and by reason of their characteristic of exhausting on solids they are useful as corrosion inhibitors, and also as waterproofing and flotation agents.

Our flow line chart indicates the various production stages and from the photograph which we reproduce, it will be seen that several of the process plants are out of doors; the boiler plant, pumps and controls are under cover. It has already been noted that the fractionating plant is automatically controlled and the same applies to the nitrile units; indeed, the whole of the plant requires the minimum of operators. Construction of the plant has called for the extensive use of stainless steel, since the hot and volatilised fatty acids are highly corrosive and any metallic contamination would result in discoloration of the fatty acids.

Dingle Bank Boiler Installation

At the Dingle Bank petroleum installation, near Liverpool, Shell Mex and B.P., Ltd., holds a "floating" stock of about 280 million gallons of liquid fuel which has to be maintained at a specified temperature. To supply the necessary heating steam a new boiler-house has been constructed and equipped with twin oil-fired boilers which will do twice the work of the original five boilers. The new plant will produce 20,000 lb of steam per hour and operate for twenty-four hours a day and seven days a week to maintain the fuel at 140 deg. Fah. and to operate the pumps which transfer the petroleum from oil tanker to shore tanks and thence to ships' bunkers and road tankers.

The building is of brick measuring 48ft by 40ft by 18ft 6in to eaves and houses two Ruston and Hornsby horizontal "Thermax" boilers, fitted with an induced draught fan, each having an evaporation of 10,000 lb per hour at 60 deg. Fah. at 150 lb per square inch. Flue gases, between 400 deg. and 450 deg. Fah. are conducted through a common horizontal flue, lined with refractory brick, at floor level to a 52ft high chimney also refractory lined. The chimney is carried on a reinforced concrete mattress supported on seven 17in diameter bored pressure concrete piles.

The feed water is chemically treated and preheated in a separate tank and the oil-burning equipment consists of a Wallsend-Howden pressure jet system, including a duplex unit of two electrically driven pumps, two steam heaters with an auxiliary 9kW electric oil heater. The oil burner arrangement, which feeds twin burners and air distributors at each furnace, consumes 920 lb of 3500 seconds Redwood 1 fuel per hour for each boiler. Each pump is capable of delivering 4000 lb of heavy fuel per hour at a discharge pressure of 200 lb per square inch. Evershed and Vignoles, Ltd., has provided the control system and the instrument panel, which incorporates smoke control instrumentation, steam flow integrator indicator and recorder, draught gauges, CO_2 recorders and recorders for feed water and oil fuel temperatures and steam pressure. Electro-hydraulic control automatically regulates the supply of fuel oil and induced draught fan speeds.

Helicopter Flotation Gear.—A Westland "Whirlwind" Mk. II recently carried out a series of about fifty landings on Southampton Water under observation by the Air Registration Board, in order to obtain clearance for civil operations with pontoons fitted. A pair of floats of American manufacture, inflated to 1¼ lb per square inch, were fitted in approximately six hours, the increase in weight being about two quarters. Each float has a long steel skid under it to protect it when the aircraft lands on a hard surface, and inside there is a shock absorber to prevent the aircraft bouncing on what are, in effect, large air springs. The aircraft was flown at its maximum weight of 7500 lb, and landings on the water were made with the engine cut at various altitudes between 400ft and 60ft. Taxying and take-off trials were also made, and an assessment made of minimum safe forward speed in case of engine failure over a range of altitudes.

Specimen Pension Schemes.—With the object of providing guidance and assistance for member-firms not already operating pension arrangements of their own, the Gauge and Tool Makers' Association has prepared and issued a series of specimen pension schemes covering works employees, works and administrative staff and non-controlling directors, and senior staff and non-controlling directors. Included also is a specimen life assurance scheme, which provides death benefit only, in the event of an employee dying whilst in his employer's service.

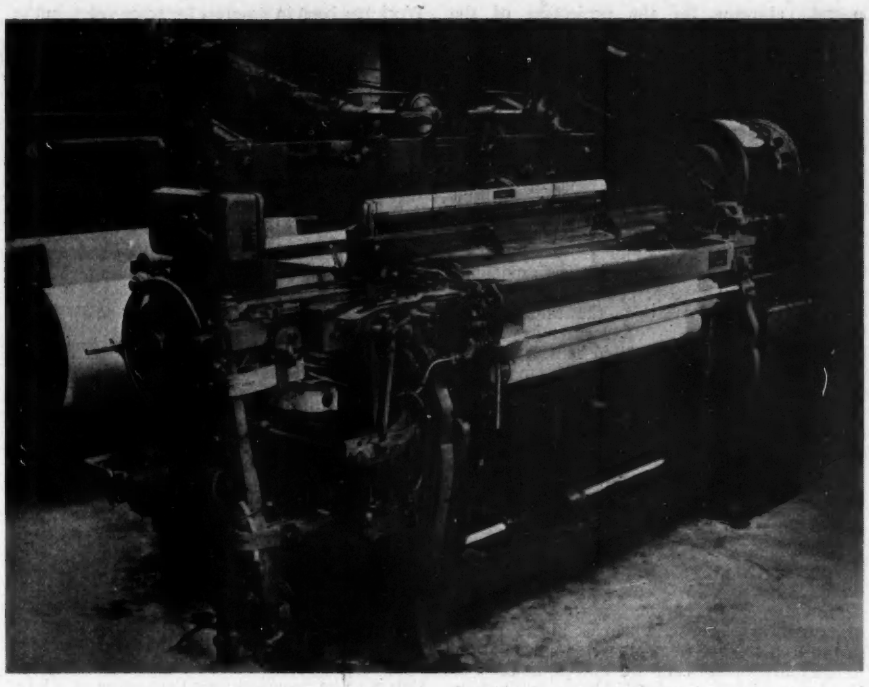
Automobile Transmission Factory

On Tuesday last week, a new factory to manufacture Borg-Warner automatic transmission equipment was opened by Mr. Robert S. Ingersoll, who, as recorded in our issue of September 2, 1955, also laid the foundation stone. Sir William Lyons, speaking at the ceremony, welcomed the ability to obtain American transmissions without purchasing them with hard currency, and he predicted that the experience of the company, which has already manufactured 6,000,000 automatic overdrives, would be a valuable asset to British industry. Mr. Ingersoll, chairman of Borg-Warner, Ltd. since it was formed in January, 1955, observed that 70 per cent of automobiles produced in the United States utilised automatic transmissions, and added that the engineers at Letchworth would develop different forms of transmission for use in Europe.

The factory, which is laid out to produce 500 transmissions each day, as well as overdrives, has nearly 200,000 square feet of floor space on one storey. It consists essentially of machine shops and assembly lines, the raw material arriving in the form of castings, forgings, or ready-to-use components. The machines are very largely of United States origin, and inspection gauges are in many cases those previously used in U.S.A., so that complete interchangeability with the original product should be assured. British plant is used where it can be substituted without affecting the end product, as, for instance, in the cases of conveyors and heat-treatment plant. The machine tools are, generally, automatic, and include hobbing and internal gear shaving machines. Transfer machines are employed on the production of transmission main castings. High levels of precision are associated with epicyclic gearing, and this is reflected in the inspection bays: the equipment here includes a "Profilometer," which drives a stylus at constant speed along a surface and continuously indicates a root-mean-square or arithmetic value of surface irregularity in micro-inches.

The automatic overdrive, as used in the Ford "Zephyr," was described and illustrated in these columns on September 23, 1955, page 449. The automatic transmission includes a single-stage hydrokinetic torque converter, a direct-drive clutch to eliminate losses when the converter is running as a coupling, and a three-speed gearbox. The converters and the gearboxes are tested on separate rigs; one of the five gearbox dynamometers is illustrated here. The transmission is clamped to the converter by the air-operated clamps seen, and the dynamometer moved up to engage the output flange. The control unit is underneath, in a well of oil at 160 deg. Fah., and the pressure gauges are connected to the appropriate tapping points. Input and output speeds and all pressures can be checked for all powers up to and exceeding design conditions. The gearbox noise and the safety devices, such as parking pawl and reverse interlocks, are also checked during this test.

The main contractor for the construction of the factory was J. Jarvis and Sons, Ltd.



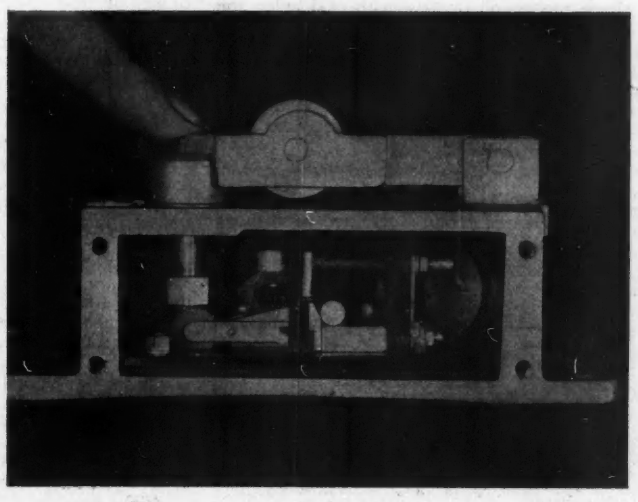
Loom fitted with snap-action limit switch for direct-on-line starting of loom motor

Snap-Action Limit Switch

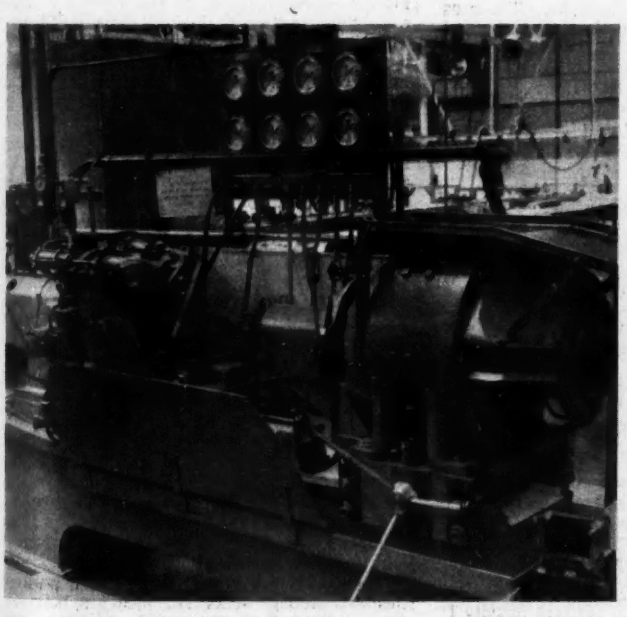
A WEATHERPROOF snap-action limit switch, suitable for the direct-on-line starting of loom motors and for other applications, has been developed by Sharp Control Gear, Ltd., Ashby-de-la-Zouch, Leicestershire. Our first illustration shows the switch fitted to the frame of a loom. It is operated by a cam fitted to the lower end of the loom starting handle, which can be seen in the centre foreground of the photograph. It will be clear that a switch of robust construction is necessary if satisfactory operation is to be obtained in service conditions. The main details of the switch can be seen in our second illustration. The switch mechanism is contained in a one-piece housing with a weatherproof, dustproof lid secured by four screws. External to the casing is the cam-operated lever and roller whereby the actuating plunger is depressed when the starting handle of the loom is moved. Turning to the interior mechanism of the switch, it can be seen from the illustration that the lower end of the plunger acts on an impregnated fibre roller mounted on the pivoted arm of a toggle mechanism. When the switch is in the closed position, as illustrated, the cylindrical moving contact forms a bridge to connect the two square-section fixed contacts, one of which can be seen in the illustration. On releasing the plunger the force exerted by a return spring moves with snap action the arm and bridge piece to the open position, breaking the circuit. A characteristic of the contact mechanism is the strong wiping action, up to six times the contact force, which minimises contact erosion and prevents welding.

The complete switch mechanism is mounted on a synthetic-resin insulating base and can easily be removed from the case for inspection.

The switch measures 6¼in by 1⅞in by 3in



Snap-action limit switch with cover removed to show mechanism suitable for direct-on-line starting of loom motor



Dynamometer for testing automatic transmissions. The eight gauges register the oil pressures at front pump, rear pump, converter, multiple disc clutch, forward servo, lock-up servo, direct drive clutch and reverse servo

overall, allowing for the projection of the plunger operating lever. Conduit entry for wiring is effected by a ¾in conduit hole at one end of the casing.

In the form illustrated the switch is intended for "off-start-run" operation. Variants with normally-open and normally-closed contacts are available. As alternatives to the arm-operated switch illustrated three other forms of capped plunger are offered. In each instance the ratings are 15A at 500V, a.c., and 10A at 24V, d.c.

Another likely use for the limit switch, besides the direct-on-line starting of loom motors, is on the Livesey type of cloth inspection machine, which is fitted with foot pedal start and stop. It could also be used for the direct-on-line starting and stopping of sectional warping machines and it could be fitted as a safety cut-out on the traverse mechanism of these machines.

African Engineering News

BY OUR SOUTH AFRICAN CORRESPONDENT

South African Railway Development

It may be said that the present intense development work now being carried out by the South African Railways and Harbours is the continuation of a programme started, in 1930, in order to meet the constant increase in the density of rail traffic. Improvements were made not only to trackyard facilities and workshops, but also to the design of rolling stock and more particularly to traction media. As a result trainloads have become heavier and trains longer. To meet these conditions some of the most powerful steam locomotives are now to be found on the South African Railways—certainly the most powerful of any operating on a 3ft 6in gauge system, which is for the most part the gauge of the S.A.R.

After suspension throughout the war this work was resumed again in 1950, when it was decided to reduce all gradients at the most to 1 in 80 compensated, while the minimum radius of curvature was fixed at 1320ft in the more mountainous country and 1650ft in the easier country. By these changes an increase in the carrying capacity of the lines from 10,000 tons to 14,000 tons was anticipated. The programme should be completed by 1960 with reductions of 11¼ miles, 10,000 deg. in curvature and1100ft in rise and fall.

Very heavy earthworks were involved in this work of regrading and deviating, including eleven tunnels of a total length of 5 miles, the longest being 6000ft. A new method of drilling was introduced in 1952, the old hand-held drills used for driving tunnels being replaced by power-fed drills. Rock removal was also speeded up by the use of longer mine car loaders so that the speed of tunnel driving was increased from 170ft to 500ft per month.

Koedoespoort Mechanical Workshops

These recently completed workshops are situated 7 miles north-east of Pretoria on the main line between the Transvaal and Portuguese East Africa on a site over 200 acres in extent, and may well be described as a self-contained city of steel and concrete. Approximately 5000 workmen are employed in these shops, which have been designed on the most modern lines. The equipment is the latest and best obtainable and is able to turn out some 500 repaired steam locomotives per annum. Facilities have been provided also for building and repairing coaching stock, and ample capacity has been allowed for the manufacture of rolling stock and other spares.

Doubling and Improvements on the Natal Main Line

The doubling of the electrified Natal main line between Pietermaritzburg and Ladysmith was another urgent matter. When doubling is complete in 1960 the carrying capacity of this line will be increased from 20,000 tons to 45,000 tons per day. Doubling has been completed between Durban and Pietermaritzburg, so that there will eventually be a double line from Durban to Ladysmith, a distance of 185 miles. Work has been in progress for some years, but in 1954 it was decided to go full speed ahead with the project.

A feature of this work is the length of the tunnels under construction. Between Mooi River and Estcourt a twin tunnel 2 miles long is being built, and a distance of 7¾ miles will thereby be saved in an overall length of 19¼ miles. On the Boughton-Cedara section, commenced in July, 1955, the longest tunnel is 3¾ miles. The distance is 19¼ miles, but will now be shortened by nearly 4½ miles. Separate twin tunnels are constructed in preference to one large double-track tunnel because this is considered more economical.

New Johannesburg Station

This is amongst the most impressive of engineering works in South Africa. The station handles approximately 500 trains a day, while it is estimated that 150,000 passengers pass through it daily. It was completely rebuilt in 1932, but within ten years it was found impossible to deal effectively with the ever-increasing traffic with which it was faced. Work on the new station was started in 1946 and will be completed in three or four years time.

The new station is of the "through" type and is planned to handle main line, suburban and non-European passenger traffic in three separate sections. The general layout is compact with ample access, including a carriageway to the station. The main line platforms are designed to accommodate motor vehicle traffic. A deck slab is to be provided over the station at a level of 20ft above the tracks, the access roads to the station and parking facilities being provided on this deck. The concourse, ticket offices, luggage offices, escalators, retiring rooms and refreshment rooms will also be provided at this level.

The main construction problem was the building of a new station at a level 13ft lower than the site of the old one, since during construction all traffic had to be kept moving. The problem was solved by dividing the work into four stages. The first stage involved the construction of a replica of the existing station at the lower level and north of the old station. This necessitated the construction of three temporary platform faces, and, except for pedestrian access from the north, there was very little interference with the old station facilities. The second stage included the lowering of the old station to the new level, the construction of the additional tracks and platforms and the final straightening out of the main lines between Johannesburg and Braamfontein.

Stages 1 and 2 have been completed and work is in progress on the third stage, which involves the completion of the suburban portion of the station with its attendant facilities. The most important aspect is the construction of the deck slabs over all the suburban tracks and platforms, and the provision of public facilities. The deck slabs will cover an area of 1000ft by 330ft.

Stage 4 includes the extension of the slabs to cover the main line tracks, but this can only be undertaken upon the removal of steam traction through the station.

The station and railway tracks in the heart of the city are not serious obstacles to the movement of road traffic, as there are eight road bridges spanning the tracks and providing connection between the north and south portions of the city. The longest of these is the Queen Elizabeth bridge, 410ft long and 108ft wide, carrying two 40ft roadways and two 10ft sidewalks. A parapet wall divides the two roadways. Concrete and steel to the extent of 14,000 tons and 800 tons respectively were used in the construction of the bridge.

Development Policy in Long Welded Rails

As a further step in the policy of pursuing the advantages inherent in the use of long welded rails, the output of these will be considerably increased when a new welding shop to be built at Beaconsfield, near Kimberley, has been completed. This will be the third shop of its kind, the other two being at Dauskraal, near Ladysmith and at Elandsfontein near Gerunston. The present output amounts to 120,000 lengths of 120ft each per annum, and the Beaconsfield shop will increase the annual output to more than 180,000 lengths. The new depot is expected to reach the production stage by the middle of 1957.

Longer rails have certain specific advantages which may be summarised as follows: (1) lower cost of maintenance, particularly of joints; (2) longer life of rail due to reduction in rail batter; (3) consequent saving in renewals; (4) smoother running and reduction in maintenance of rolling stock; (5) greater passenger comfort; (6) elimination of creep; (7) better conductivity for track circuits; (8) less track bonding on electrified lines.

The S.A.R. is for the present concentrating on the 120ft lengths, which previously were formed from three standard 40ft rails joined together. In 1937, flash-butt welding of rails into 120ft lengths was introduced for the first time and about 4500 miles of track were thus laid. Research into the use of extra long welded rails is also proceeding, there being many lengths of 240ft, 480ft and 960ft in the track, apart from those in tunnels where lengths up to 3000ft have been laid. These expectionally long lengths are placed in tunnels because of the more uniform temperature there than in the open.

The 120ft rails are transported on two 60ft wagons with a pivoted cradle resting on each. Thus the cradle remains straight on the curved track, while the wagons swivel under the cradle in the same way as the truck bogies swivel under the trucks.

Soil Foundation Failures

It is fairly well established that the task of the engineer who has to design the foundations for large buildings in South Africa is not an enviable one. In the first place, he is likely to be dealing with partially saturated soils about which far less is known than the fully saturated soils of Europe and North America, where most of the theories of soil mechanics were developed. In some of these soils he is liable to meet "heaving clay," which will rise up unevenly after the building is completed with resultant cracking of the structure unless special precautions have been taken. On the other hand, he may encounter loosely packed soils which will consolidate and sink as they gradually take the load of the building. Each of these soil types leads to characteristic failures which can be easily recognised by the competent soils engineer.

Within the last year, however, several occurrences of a new soil type which behaves like the one and results in cracking like the other, have been brought to the notice of the S.A. National Building Research Institute. These soils, which are known as "collapsing sands," consist of loosely deposited materials and when dry have some cohesive strength due to a cementing agent. This dry strength is a snare for the unwary, for if the soil becomes wet as a result of excessive rain or leakage from water pipes or drains, the binder loses its strength, and if the soil is carrying load it collapses suddenly causing considerable damage to the building. The pattern of cracking from this cause is very similar in appearance to that caused by heaving soils, and it is probable that some cases in which heaving soils were blamed, were, in fact, due to soil collapse of this nature. At this stage it seems likely that the most satisfactory method of dealing with this problem will be to found below the troublesome material, or design the structure to cope with the settlement. There may be a possibility of strengthening the soil by the injection of suitable chemical agents, as the structure of the sands would obviously lend itself to this form of treatment. There is very little local experience of this type to draw on, so the S.A.N.B.R.I. has commenced its investigation into this problem with a study of the chemical composition of the soil constituents and cementing agents with a view to modifying them in such a way as to resist the weakening action of water. As these collapsing sands do not appear to be associated with a particular geological formation it is not at this stage possible to predict all the areas where they are likely to be found. They are, however, fairly common in Southern Africa and have been reported in such widely separated districts as Pretoria, Witbank, Lichtenberg and Waterberg, and in 'Nkana in Northern Rhodesia.

Industrial and Labour Notes

Employment in 1955

The annual report of the Ministry of Labour and National Service for 1955, just published, shows that the total working population of this country mounted to over 24,000,000 during the year, a record total of 24,135,000 being reached in November, 1955. The labour force in civil employment rose to over 23,000,000 in August, 1955, and at the end of the year still approximated to that total. Despite this rise in the number of persons in civil employment, the unsatisfied demand for labour increased and the number of vacancies in December, 1955, was 382,200, some 44,000 more than the previous December. During the year under review over 2,600,000 men and women were placed in employment by Employment Exchanges, whilst 16,000 people were placed by the Appointments Service and 430,000 young people by the Youth Employment Service. It is pointed out in the report that as the gap between the demand and supply for labour widened the pressures on the economy arising from full employment were accentuated. Claims for increased wages were made in most industries and in the main were settled in a constitutional way within the industries. Nevertheless, labour was restive and the number of working days lost through industrial disputes was the highest in the post-war period and totalled 3,781,000. Of the time lost in industrial disputes about 45 per cent of the total was lost in the transport industries, and nearly 30 per cent in coal mining. The rise in the average weekly rates of wages was greater than in 1954 and again outstripped the increase in retail prices as measured by the interim index.

Notes on the manpower position in various industries show that there was a decrease of 5200 in the coal mining labour force and 16,000 in the railway industry. The numbers employed in the gas, water and electricity supply industries continued to increase. All groups in the manufacturing industries, with the exception of textiles and clothing, showed a rise in employment. The most marked rise in this section was in the engineering, electrical and vehicle groups, where there was a manpower increase of 128,000.

The average number of unemployed during the year was 232,300, compared with 284,800 in 1954, and the total for July, 184,900, was the lowest for any month in the post-war period. The lowest unemployment rates for the year were in the Midland and North Midland regions, whilst the highest rates were in Scotland and Wales with 2·3 per cent and 1·7 per cent respectively. There was some increase in short-time working in the manufacturing industries, but the number at no time exceeded 1 per cent of all operatives. The overtime worked in the manufacturing industries rose to a record height in November.

Maintaining Full Employment

On Wednesday of last week the principal activities of the British Employers' Confederation were described by its director, Mr. George Pollock, Q.C., in an address to the Rotary Club of London. In that address, Mr. Pollock said that, according to the economists, the major problem was how to maintain full employment in a welfare state, without continuous inflation. He suggested, however, that the practical problem was how to maintain full employment in the face of the keenest industrial competition the world had ever known, competition both in price and in quality. Britain, Mr. Pollock commented, no longer sold many goods merely on her reputation for craftsmanship ; she sold them when they were " best at the price."

Mr. Pollock went on to say that between 1950 and the first half of 1955, before the recent wage increases took effect, average labour costs in the United Kingdom per article rose by 25 per cent ; in the U.S.A. they rose by 10 per cent, and in Western Germany they remained almost unchanged. During that same period of five years our share of world trade steadily fell, and was roughly 25 per cent less in value in 1955 than it was in 1950; the American share was only 10 per cent less, and Germany more than doubled her share. Last year, Mr. Pollock added, world trade in manufactures expanded at twice the rate at which the United Kindom's exports expanded during the year. The slower expansion of United Kingdom exports to O.E.E.C. countries was due mainly to their failure to stand up to price competition from Western Germany, the U.S.A. and from other West European countries.

The maintenance of full employment, Mr. Pollock continued, was the concern of all right-thinking men, but whilst jobs were chasing men neither employers nor trade unions could stop wage inflation. Overfull employment, he suggested, was the gravest menace to full employment. In a free enterprise state, new enterprises must constantly be starting and existing profitable enterprises must be expanding ; new factories must attract workers away from jobs they already held. In a large measure, Mr. Pollock observed, increased earnings in recent years had come not from negotiation of new rates, but from employers competing among themselves for men who were in short supply. Mr. Pollock ended his talk by saying that the biggest step which employers could take was to utilise their existing manpower on a more efficient basis so that men were released for jobs for which they were urgently needed, not only in the mines, but in other factories where there were still acute shortages of manpower. If, Mr. Pollock said, the position could be reached when we no longer employed three men on a job which could be done by two, we should defeat the menace of what the Prime Minister had recently described as " poverty by stages," and find ourselves instead on the path of prosperity by stages.

Motor Vehicle Production

Board of Trade figures for the production of road vehicles in this country show an increase in June, the weekly average being 23,200 vehicles, against 20,200 in May. Production in June, 1956, was 116,083 vehicles (83,043 cars), and in June, 1955, totalled 118,096 (85,967 cars). For the second quarter of the year the figures were, in 1956, 281,173 (197,584 cars) and in 1955, 309,802 (226,770 cars). For the first half of the year the totals were, for 1956, 590,858 (412,907 cars) and for 1955, 628,220 (460,740 cars).

Exports also rose over last month, except for goods vehicles ; the total was 43,804 (30,428 cars), against 44,445 (29,752 cars) ; in June last year exports (affected by a labour dispute in the docks) were 31,374 (22,920 cars). For the second quarter of the year the total was 130,391 (88,756 cars), against 131,270 (94,568 cars) last year. Over the first half of the year the corresponding figures were 253,508 (170,352) this year and 278,162 (200,360) last year. One market, the U.S.A., showed a marked increase in business in June ; 4200 cars were shipped there, against 10,000 in the preceding five months. The figure for last month represents roughly 14 per cent of Great Britain's car exports, against the five months' figure of 8 per cent.

Necessity for Job Changing in Industry

Reports have been published of an address by Mr. Macmillan, the Chancellor of the Exchequer, to the National Production Advisory Council on Industry in London last week. He said that the sooner the changes in employment now taking place in industry were completed the better it would be for the country's economy. He indicated that to keep up with competition new lines of production were essential and that naturally involved changes in employment. At present, with employment nominally at a peak and more and better productive plant than ever before, production itself was not rising. This state could not continue and the faster the necessary changes were made the faster the country could progress. To minimise the human difficulties occasioned by such changes more consultation was needed between Government and industry and between workpeople and employers. Mr. Macmillan pointed out that if employers retained labour they could not fully employ, or if workers stayed in three-quarter or half-time jobs, necessary changes would be slowed up and the country would be impoverished. It was through expansion on a basis of increasing efficiency that the country would find the positive permanent answer to inflation, and efficiency and expansion called for two things. First, more and better plant and enough pay for a great investment programme were necessary. Secondly, there was required a readiness to get the best out of such plant, and people did not do that if their attitude towards their work was too restrictive or defensive.

Summary Sheets of British Standards

The British Standards Institution has begun the publication of " summary sheets " which provide in very concise form, the relevant working details, particularly tables of dimensions needed by standards officers, engineers and designers, in their day-to-day work of applying British Standards. The first of these sheets contains summarised versions of B.S. 1768 for unified precision hexagon bolts, screws, nuts (UNC and UNF threads) and plain washers, normal series. It is pointed out that these sheets will be particularly useful to firms requiring a number of copies of a table or tables contained in a standard and having no facilities for reproducing them or finding it uneconomic to employ draughtsmen for copying the necessary details. While every care is being taken to ensure that the summary sheets contain all the essential information, the facts are necessarily presented in as concise a form as possible and where further explanatory details are required users should obviously refer to the parent standard. Many standards do not lend themselves to summarised presentation, and the most suitable are those consisting mainly of tables of dimensions. It was for this reason that standards for screwed fasteners have been chosen to initiate the project.

United Kingdom Trading Figures for June

In announcing that the exports from the United Kingdom in June last were valued at £276·1 million, the *Board of Trade Journal* points out that this latest figure shows that the rise in exports is being maintained this year at a faster underlying rate than during any year since 1951. The exports for June were a little below the record level of the month before, and once again benefited from the inclusion of a large value for the delivery of completed ships to overseas purchasers, which totalled some £16,200,000. The June figure brought the total value of exports for the second quarter of 1956 to over £815 million—£40,000,000 more than in the first quarter. The value of exports for the first half of the year, at £1591 million, was 14 per cent greater than the corresponding period of 1955, when shipments were badly affected by strikes.

The rate of expansion this year has been achieved despite a fall in car exports, a continuation of the decline in cotton textiles, and a little more than maintenance of last year's levels in textiles other than cotton, and in consumer durable goods other than cars. The bulk of the expansion has been in capital goods with very big increases in exports of aircraft and ships, and substantial increases over a very wide range of machinery and electrical equipment.

Imports in June rose to a value of £339·9 million, and in the first half of the year totalled £1977 million, or nearly 4 per cent more than in the same period of 1955. Re-exports in June were valued at £12,200,000 and brought the total for the half-year to over £80,000,000. The total visible trade deficit of the United Kingdom for the first half of 1956 was £305 million, or £150 million less than the first half of 1955.

Association Technique Maritime et Aeronautique

THE fifty-fifth meeting of the Association Technique Maritime et Aeronautique was held from May 29th to June 2nd at the Maison des Centraux, 8, rue Jean-Goujon, Paris. Proceedings opened on Tuesday afternoon, May 29th, with the general meeting and before the reading of the papers the president, Mr. Georges Bourges, gave his survey of developments during 1955.

He commented upon the French naval reconstruction programme and the development of supersonic aircraft, together with the current investigations into the possibilities of atomic propulsion for submarines. Considerable progress had been made in the building of the aircraft carrier "Clemenceau" at Brest and a sister vessel, to be named "Foch," at Saint Nazaire. He remarked upon the aircraft carriers of other navies and went on to say that the anti-aircraft cruiser "De Grasse" would shortly join the fleet and that another cruiser, "Le Colbert," had been launched recently. A ship to carry helicopters and which would also serve as a replacement for the training ship "Jeanne d'Arc" was under consideration. The president went on to praise the work of the light escort vessels. The submarine "Narval" is undergoing trials, as are also certain new materials and items of equipment. With regard to machinery, attention is being paid to the problems of high pressures and temperatures, free piston gasifiers and gas turbines, controllable pitch propellers and to the development of 400 c/s electrical motors.

With regard to the merchant navy, the president referred to the implementation of rules approved at a number of conventions and remarked upon the development of special cargo vessels and the size of oil tankers now building. He went on to recall some of the items of technical interest published during the year and to review some of the technical problems upon which work is proceeding, particularly that of welding quality steel and the welding of aluminium alloys. Machinery trends in France and abroad were also examined.

Turning to developments in the air, Mr. Bourges referred to the record speeds recently attained and to several of the latest French aircraft including "Trident II" "Taon," "Caravelle" and others which made their first flight during the year.

The reading of the papers began with the presentation of "Airplane S.E. 210 Caravelle" by J. Dor, who said that the originality of the aircraft lay in the position chosen for the jet engines. He claimed that this particular arrangement resulted in certain advantages with regard to: the aerodynamic properties of the cellule; propulsive efficiency; construction; the fire risk; passenger comfort and operational economics. "Statistical Evaluation of the Stresses Undergone by Ships at Sea" was the title of the paper read by H. de Leiris in which it was stated that the complexity of the strain diagrams recorded on board ships at sea made statistical analysis the only one possible. Regarding the practical use of such measurements it was considered that the substitution of a direct statistical record, given by the machine itself, for the usual record would prove of advantage. The basis of such statistics were discussed and the paper went on to describe a prototype statistical extensometer and the programme of laboratory tests, the results of which are considered to be encouraging regarding its use on board.

On the morning of Wednesday, the meeting opened with paper "Arithmetical Computers in Aviation and Naval Applications," by H. Boucher. After briefly reviewing the arithmetical principles the author mentioned several examples of computers used for military purposes in foreign countries. He stressed that, contrary to general opinion, French industry is equipped to tackle the various problems, and analysed the structure of a computer suitable for a large warship. The advantages and disadvantages of such computers were examined and the author concluded that the advantages outweighed the disadvantages. The next paper, given by A. Sciama, was "Electronic Computation—its Technique and Application to Naval Problems," and mentioned the value of computers in carrying out research and in scientific business management. The paper included a description of an electronic computer together with its equipment and method of working, and also considered its application to naval problems.

Mr. Jourdain presented the next paper, entitled "Use of the Log During Sea Trials," and considered the log as a direct means for measuring the ship's speed relative to the water. From this point of view the author showed that, even allowing for errors due to service conditions, log data provide a valuable cross check by which errors relative to other measurements may be discovered. Various examples of such use were examined and the author concluded that it would be of interest to make more use of the log on sea trials with a view to establishing the accuracy of the instrument. "Measuring the Thrust of Ship Propellers" was the title of the paper read by J. Chevallier and R. Ferry. The obvious value of having accurate knowledge of thrust of the propeller in analysing trial data was commented upon and also the fact that thrust measurements were often doubtful. The relative importance of errors at low speed was noted and also that analyses of the sources of error called for certain simple corrections. Trials carried out at sea and on the test bench with a simplified form of measurement have enabled a method to be defined which practically eliminates errors due to the friction in the packing. The fifth paper of the morning session was "Applications of the Decca Navigator to Measurements at Sea," by Mr. Jourdain. Under favourable conditions the Decca navigator, it was recalled, can supply accurate data for use with other measurements in sea trials, and the paper gave examples of the plotting of turning circles, speed and deceleration measurements carried out using the Decca system.

"Maintenance of Diesel Prime Movers" was the title of the first paper in the afternoon, and the author, E. Cotti, after making comparisons between the maintenance of diesel engines and steam turbines, went on to consider maintenance in terms of construction, equipment and installation on board ship. Different designs of ships and engines were examined from the point of view of their maintenance, and also the influence of heavy fuel oils upon maintenance with special reference to slow-speed engines of large bore. In the next paper, "Problems and Results of Supercharging Large Two-Stroke Engines with Transversal Scavenging," R. de Pieri gave some general information on the supercharging of two-stroke engines and paid particular attention to those engines with transversal scavenging such as the high-powered Fiat units. Results of tests and research work carried out on various supercharging systems were included and referred to the system finally adopted, which uses pressure-charged turbines and centrifugal blowers working in series with reciprocating scavenging pumps. Diagrams showed the main operating results and the paper included service results with the first unit in service. The following paper, "The Resistance of Hydrogliders," by S. Marsich, recalled earlier investigations into the behaviour of gliding surfaces of constant transversal section and recorded the resistance corresponding to every angle a ship may make with the horizontal. A graphical method gives the resistance corresponding to the actual position of the ship

Fig. 1—Chantiers et Ateliers du Rhin. General view showing the layout of the yard

Fig. 2—The Alsthom works at Belfort

on the water and the paper concludes with practical notes about the design, and the proportions to be adopted, of a ship's bottom with or without a step.

The fourth paper of the afternoon was "Supplementary Notes on the Linearised Potential with a Free Surface Applied to Investigations of Ships' Forms," by R. Guilloton. The object of this paper is a detailed examination of the ideas on which this potential is based in order to find a starting point for a method to improve approximations. A table gives the values of the functions expressing the pressure and flow derived from this potential, for an elementary solid, over the whole field for which it is defined. Also in the paper is an examination of the forces and moments acting on the solid owing to the potential. Tables enable the resistance to motion to be calculated for any form with linearised potential from the surface wave. A. J. W. Lap gave the next paper entitled "Scale Effect in the Resistance of Shaft Bosses and Shaft Brackets of Twin-Screw Ships," in which the author states that the additional resistance created by well-located appendages can be separated into friction and wave resistance by applying the three-dimensional Lap-Troost extrapolator. Extrapolating from the model results to the ship automatically takes scale effect into account and test results with the "Lucy Ashton" model fitted with appendages proved the correctness of this new method in the same way as the tests carried out at the experimental tank at Wageningen using models with and without appendages. The author concludes with a short account about the factors affecting shaft bossing and brackets.

The last paper of the session, "Remarks about the Propulsive Behaviour of Trawlers," by Mr. Jourdain, records the propulsive equations of a trawler when fishing in a stream parallel to the course, and shows by simple diagrams the influence of the stream upon speeds. Examples of trial data are given and the paper points out the need to amplify the data to appreciate trawler qualities and possible improvements.

The meeting opened on Thursday morning with the reading of "Air Generator-Hydropump for Pumping and Hydraulic Propelling Services," by J. P. Polouektoff. The pumping results obtained by using a hydrostatic filling pump and an air generator gas turbine are given and the paper examines the possibility of using free piston generators and summarises the working conditions and the theoretical efficiency. An investigation into the use of this plant for ship hydraulic jet propulsion is also presented. The next paper was "Application Limits of the Bearing Line Theory to the Calculation of Airplane Wings fitted with Spoilers," by A. Fauquet. This paper completes a work of the author who had shown that, in a particular instance, the theory of the bearing line is valid for calculating the drag, lift and the rolling and yawing movements of aircraft wings fitted with spoilers. The application limits of this method are given when the wing extension is reduced and the spoilers fitted closer to the leading edge and the importance is stressed of the knowledge of these limits to the designer in determining the efficiency of spoilers used as rudders and ailerons.

"Analysis of the Theoretical Working of the Gas Turbines by Means of a Graphic Representation," by L. Poincare, was the title of the third of the morning's papers. Consideration of the absolute temperatures, at different cycle points, in terms of actual temperature when compression is completed or by considering the ratio of these temperatures, is stated to produce a diagram which permits the examination of the theoretical working of a gas turbine. Drawn for known data of the problem the diagram can be used for other values provided that the ordinates and abscissæ are drawn to different scales. Th. Seifferlein read the next paper which was "Combustion in Aircraft Jet Engines." The paper deals with certain basic aerodynamic and thermodynamic laws as applicable to combustion and applies them to the combustion chambers of jet engines and statoreactors, and to preheating devices.

On Thursday afternoon, the first paper was "A Solution of the Problem of the Distant Level Indicator for High-Pressure Vessels," by J. Legris, which states the principle and briefly describes a distant level for indicating the level of a liquid or the separation surface of two liquids, of different density in a high-pressure vessel. F. Babin read the next paper, "Built-in Aircraft Aerials," which includes eight sections by a number of technical experts, dealing with various aspects of the problem. The following paper, by J. J. Villiers and entitled "The Azimuth-Distance Means of Aid to Middle-Distance Civil Air Navigation," presents the I.C.A.O. aids to middle-distance air navigation and gives data about their international statute, the number of stations as well as the accuracy of the systems. The future development programmes of the members of the I.C.A.O. are referred to and it is stated that the present deadlock is more apparent than real.

A. Gras and J. Lochard were the authors of the next paper "The Decametric Wave Radiogoniometry Applied to Aeronautical Radionavigation." The classification of radiogoniometers is discussed and the use of radiogoniometry in civil aeronautics followed by an enumeration of the difficulties in setting up decametric radiogoniometers in overseas territories. Radionavigation systems are compared and the use and organisation examined of a radiogoniometric network serving as a radionavigation system. The conclusions are applied to a desert zone. The fifth paper was "Fluttering Tests of a Wing Model," by R. Landais. "Effects of Steering Gear Defects upon the Quality of Steering Servo-Motors," by Monsieur Nicolas was the last paper on Thursday. The paper draws attention to the way in which servo-motors are affected by the defects of steering gear appliances and shows that tolerances should be determined beforehand. Investigation of the effects of defects helps to determine the loss of gain and the phase lag due to the steering gear and so estimate the consequences upon the stability of the system. Elasticity, friction and inertia effects are examined and it is noted that the harmonic method is applied despite the fact that certain phenomena follow non-linear equations.

The meeting continued on Friday morning with the reading of "Complex Aplexical Vessels formed by Truncated Spheres, Cones and Coaxial Cylinders," by J. Legris. The paper states that considered individually the cylinder, cone and sphere are capable of constituting thin aplexical vessels. However, maintaining aplexism in composite vessels obtained by placing pieces of the above surfaces side by side can be achieved only by, observing geometrical rules, selection of thickness and by joining solids carefully located and dimensioned. The paper consists of a survey of reflections on this subject and refers to the constructional facilities afforded by circular section joining reinforcement. "Non-Destructive Measurements of Hull Plating Thicknesses by Ultrasonics," by E. Antoni was the next paper. It recalls the physical basis of the ultrasonic resonance method and describes the main equipment and also records its application to three identical ships unequally corroded.

H. E. Jaeger and J. S. Folkers were the authors of the next paper, entitled "Calculating Bulkhead Scantlings by Using the Theory of Collapse Developed by Professor Baker." The theory is explained and an indication given of how it may be used for calculating the scantlings of watertight bulkheads. "Measurement of the Strains in a Sternpost set up by Steering," by H. de Leiris records the strain measurements made on a cast steel sternpost during turning and course trials. It is considered that the results are an accurate record of the strains in the post and that they indicate the maximum strain to be within permissible limits.

The first paper of the afternoon was "Hold Moistures—the Danger They Present and an Investigation of the Proposed Methods of Prevention," by P. L. Bain and A. O'Connell. After referring to two typical cargoes, motor-cars and jute, the paper discusses the processes generally employed to prevent the formation of moisture and puts forward the "dewpoint control" method, which uses a source of dry air production. In the next paper, "Survey of Recent Works Regarding the Oscillation of Harbour Waters," J. Kravtchenko analyses recent works carried out at Grenoble on the harbour problem with reference to determining the oscillation amplitude and phase of the free harbour water surface. The third of the afternoon's papers was "Modern Norwegian Cargo Ships with Accelerated Handling Equipment," by P. L. Bain. This stresses the importance of handling problems on cargo ships, describes a ship especially designed for easy handling of cargo and states the results obtained in service. G. Bouvier presented the next paper, "Protection of Low-Voltage Installations by Cascade Circuit-Breakers—the Problem of Release Selectivity," which examines the following: currents due to a fault, behaviour of cascade circuit-breakers, selectivity releasing devices and the principle of limited selectivity.

"Shipbuilding and the New Electrical Regulations—Experience of the 'Ville de Djibouti,'" by J. Trottier, was the next paper presented, and the final paper of the meeting was "Notes on the Reliability of Electrical Installations on Board Ship," by C. F. Maupas, who examines the different aspects of the safety problem set by the electrical control of the ship and engine-room auxiliaries. The question of connecting the generating sets in parallel is analysed and also the

problem of electrically protecting the electrical installations is discussed.

Annual Banquet

This year the annual banquet of the Association Technique Maritime et Aeronautique was held at the Hotel George V., Paris, under the presidency of Monsieur Henry Laforest, the Secretary of State to the Air Force. A company of about 170 attended the dinner, including officers of the French Navy and Air Force, representatives of the various government departments associated with the armed services, shipowners, shipbuilders, marine engineers, Naval, Military and Air Attachés of Argentina, Great Britain, Greece, India, Israel, Italy, Jugoslavia, Norway, Portugal, Russia, Thailand, and the United States of America, and representatives of the technical press of Great Britain. The company were welcomed by Monsieur Georges Bourges and addressed by Monsieur Henry Laforest. While attending the meeting the British technical journalists, as in previous years, were able, through the kind offices of the Chambre Syndicale de Constructeurs de Navires et de Machines Marine, to pay a visit to a number of shipbuilding and engineering establishments. From Paris the party made the journey to Strasbourg to visit the Société des Chantiers et Ateliers du Rhin, which was founded in 1937 and since the war has been expanded and modernised. This is the only yard between Basle and Mannheim and has an area of 132,000 square yards, within which are modern prefabricating, boiler, machine and woodworking shops. There are adequate crane facilities at the berths and in the shops. Some idea of the unique layout of the yard can be seen from the illustration on page 136. There a total of eighteen berths are arranged on either side of a central railway. On one side are four building berths and six repair berths, while the remaining eight berths, used for repair work, are on the other side. All the berths are without gradient and are fitted with four sets of rails, and the ships, whether new building or repair jobs, are transferred from the building blocks to a carriage fitted with hydraulic jacks in a manner similar to that employed for transfer to launchways. The carriage is then hauled to the central railway, where the movement is at right angles, and the ship is moved sideways to the launching basin, the carriage passing over a curved ramp down to the water to allow the ship to float off. The reverse procedure obtains for the removal of a ship from the water, and arms outboard draw the ship towards the bank and into shallow water to a point where it rests on the cradle. The staff number about 500 and approximately 300 barges and tugs are repaired each year. New work generally consists of barges and tugs for river service, but present orders, which are sufficient to keep the yard busy until 1957, include tankers of 1000 tons for the Rhine, and of 700 tons for the Rhone, and many smaller units. It was of interest to note that the yard had completed three coasters of 500 gross tons for Norway and were building two more of 750 gross tons. Before leaving Strasbourg the opportunity was taken to pay a brief visit to the port, which has an extensive dock system and an area of about 1370 acres, including 225 acres of waterways. Over 12,000 vessels enter the port each year and the Rhine traffic reached a total of 6,366,000 tons in 1955.

From Strasbourg the group journeyed by road to Belfort, in which town is situated the Société Generale de Constructions Electriques et Mecaniques Alsthom. This name was assumed in 1928 when the Société Alsacienne de Constructions Mecaniques combined with the Compagnie Française Thomson-Houston, although the former company was established in Belfort in 1879. The plant, of which we reproduce an aerial photograph, occupies an area of about 150 acres and employs a labour force of approximately 10,000. To maintain a high standard of technical skill the company runs a well-equipped apprentices' school, where about 100 boys, of fourteen years of age, enter each year to undergo a three-year course of instruction in one or other of the skilled trades. Something approaching 5000 tons of raw material enter the works each month to be used to produce a wide variety of products. In the field of heavy engineering, these include boilers of various designs, steam turbines, gas turbines, Pelton wheels and Kaplan and Francis turbines for high, medium and low heads. Electric motors, both small and large, are manufactured and provide power in a wide variety of industries. Installations for power stations are built, including turbo-alternators up to 125,000kW, while sets of 250,000kW are on order. Marine turbo-electric machinery is built, the latest ships to be so equipped being the "Kairouan" and the most famous being the "Normandie," which was powered with four 33,400kW units. Another major department of the company is that producing diesel-electric and electric locomotives, and we were afforded the opportunity of making a run, over the company's private track, in a "C.C." series "14,100" electric locomotive. It will be remembered that the company's "CC 7107," 1500V, 5000 h.p. locomotive attained a speed of 206 miles per hour in 1955. Fig. 3 shows some of the locomotives under construction in the erecting shop.

The next visit was to the Société des Forges et Ateliers du Creusot (Usines Schneider), at Le Creusot, which were started about 120 years ago. At present the works employs 13,000 people, and occupies about 900 acres, of which 125 acres are covered. The activities carried out at the works fall into three main groupings, namely, the making of steel, the making of castings and forgings and heavy engineering. Ordinarily, alloy and fine grain carbon steels are produced, of which 75 per cent goes to the mills and 25 per cent goes to the foundry. Of the production from the mills 75 per cent is sold and 25 per cent is retained for use in the company's own products.

At the open-hearth steel works the maximum yearly output is 300,000 tons, and the foundry, said to be the largest in Europe, produces large castings of up to 200 tons. Two electric furnaces of 80 tons capacity are planned to be built to replace older gas-fired furnaces. A further 80,000 tons a year of steel are produced in the electrical steel works. In the rolling mills, billets, round bars and plates are produced, shipbuilding plate being sent to the Ateliers et Chantiers de France. In the forge are a number of presses, including one of 6000 tons.

Steam turbines are built to Westinghouse designs, many units of the standard 125,000kW size being under construction for the Electricité de France, as is also a 6000kW gas turbine of coaxial design having a compressor of six axial stages and one radial stage driven at 5200 r.p.m. by its own turbine, and a 3000 r.p.m. power turbine. Electric and diesel-powered locomotives are built at Le Creusot, the electric motors being supplied by the Paris factory. The workshops are well equipped with machine tools for dealing with parts for large and small diesel engines, and for the various designs of hydraulic turbines. Burmeister and Wain diesel engines are built, as is the company's own design of submarine diesel engine. Radiator-cooled, single-cylinder farm tractors are also made.

Fig. 3—Erecting shop for electric locomotives

Expansion of Swedish Shipyard

In the ten years of its existence, the Swedish shipyard of Uddevallavarvet has undergone a remarkable development. It now employs 1800 workers, and plans to expand by another 500 this year. In 1955 its output was the fourth largest in Sweden, with a deadweight tonnage of 113,000, including a 32,500-ton tanker, the "Josefina Thordén." Four 34,000 tonners are at present building or on order. A floating dock capable of accommodating vessels up to 24,000 tons was added to its facilities at the beginning of the current year. Recently it was announced that Uddevallavarvet had acquired the Skandia diesel works at Lysekil nearby from the Bergbolagen group. The company now proposes to build engines of 100 h.p. to 3500 h.p. at this plant. A shore property of 1,000,000 square feet is shortly to be taken over by the yard, whose Uddevalla facilities are proving insufficient. The yard has recently received the largest single order placed in Sweden. It is for the construction of ten 40,500-ton tankers for the Trinity Tanker Corporation, U.S.A. Six tankers have been definitely contracted for, while four more are to be undertaken if they can be built within a specified time. The first of these ships is to be delivered in 1959. The order is reported to be worth about 80,000,000 dollars.

Pipeline for Milk

At St. Martin, near Sierre, in the Swiss canton of Valais, a pipeline for milk has been constructed. A second pipeline has come into operation at Grimentz, in the Val d'Anniviers. It serves the purpose of transporting the milk from the higher meadows, where the cows are grazed in the summer, to the central dairy at the village. This saves transport costs and materially assists with the cheese-making, which can now be carried on at the same centre all the year round. At Grimentz, a pipe, made of "Symalen" plastic and about 1km long, leads from the top station, at 2000m above sea level, to the dairy, which is some 400m lower down the mountain. When the pipe is not being used for conducting milk, clean water is passed through it to keep it fresh. After use, a detergent is used with the rinsing water. The end stations are connected by telephone to ensure correct operation. The pipeline at St. Martin is similar, but longer. If the present scheme proves satisfactory it is hoped to extend the system to a length of about 7km.

Industrial Nuclear Facilities Works in Virginia

BY OUR AMERICAN EDITOR

No. I

The nuclear facilities works of the Babcock and Wilcox Company at Lynchburg, Virginia, went into operation in May. The installation is believed to be the first major facility in the United States erected entirely at private expense to manufacture and test nuclear fuel elements and related reactor components for peaceful use. The works comprise a fuel element fabrication shop with metal casting, rolling, welding and machining equipment and a reactor critical experiment facility to be used for the study and testing of reactor core components.

THE growing interest in the commercial application of atomic energy has now led to the opening of the first privately financed fuel element fabrication facility in the United States. The installation (Fig. 1) is known as the Nuclear Facilities Works of the Babcock and Wilcox Company and is situated near Lynchburg, Virginia, on a 520-acre site along the James River. The works is divided into two spheres of activity—a nuclear fuel element fabrication unit, and an experimental unit where reactor core components will be studied and tested. The fabrication building, covering an area of 32,000 square feet, has complete metal casting, rolling, welding and machining equipment to turn out flat-plate fuel elements. Production has already begun here on a year's supply of fuel elements for the materials testing reactor of the U.S. Atomic Energy Commission at Arco, Idaho. Delivery of the first thirty-five assemblies under this contract is scheduled to take place next month. The Babcock and Wilcox Company also has contracted to design, fabricate, erect and test the first American privately owned nuclear steam generator for the Consolidated Edison Company of New York. Production of fuel elements for this reactor will begin at Lynchburg as soon as final design details have been completed.

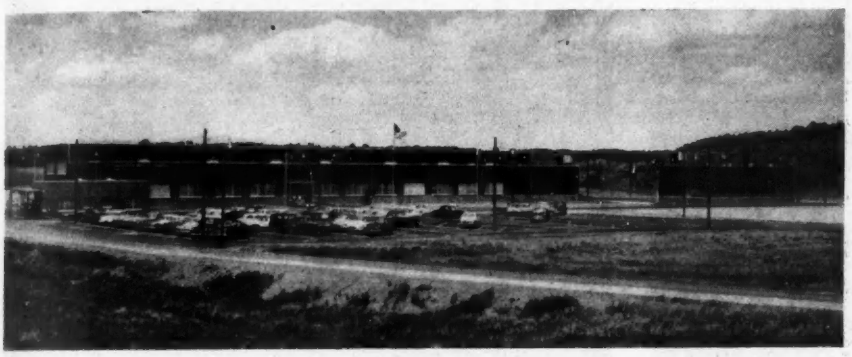


Fig. 1—Nuclear fuel element fabrication works at Lynchburg, Virginia, with boiler-house at right

The initial operations in the new experimental facility will be devoted to determining the nuclear characteristics of the Consolidated Edison reactor design. The first core assembly, made to one-quarter scale, will be tested at a power level of only about a watt. Thorium, which is converted to new reactor fuel as fissioning takes place, will be a component of the fuel elements employed in tests here, representing the first nuclear use of thorium by private industry in America. In planning the fabrication plant provisions were made to add the facilities necessary to make pin, rod and cylindrical fuel elements, as well as the flat-plate elements now in process.

The Babcock and Wilcox Company has been active in the nuclear field since 1942, when it worked on equipment for the "Manhattan Project." For the past twelve years, however, the company has devoted most of its efforts in the nuclear field to developing methods for the conversion of atomic energy to usable power. Besides its current contracts for the Consolidated Edison reactor and the materials testing reactor, the firm is building a "swimming pool" research reactor for the University of Michigan, and a similar, but larger, unit for the Brazilian government. Recently the U.S. Atomic Energy Commission selected the company to design, fabricate and operate a liquid metal fuel reactor experiment, and contract negotiations are now in progress concerning this project. Babcock and Wilcox has also signed an agreement with the Florida Power and Light Company, the Florida Power Corporation and the Tampa Electric Company to develop, design and construct a large nuclear power reactor to be situated within the service area of the three companies. The firm is also studying the feasibility of homogeneous reactors within the Nuclear Power Group, and is a member of Atomic Power Development Associates and the Power Reactor Development Company.

Works Structures

Bordering the works site on three sides are the tracks of the Chesapeake and Ohio Railroad and the Old Dominion Canal, which run along a bend of the James River. Rising on the south-eastern perimeter of the site is the 800ft high Mount Athos. The major operations are centred in two main areas of the property. The first one, consisting of a manufacturing shop, a gate house, a boiler-house and a maintenance building, is the fuel element fabrication area. About 1200 yards distant, the critical experiment facility was recently completed. In addition, there are buildings and equipment for the tank farm, sewage system and water supply. To provide level sites for the works structures, more than 80,000 cubic yards of earth were moved.

The fuel element fabrication shop (Fig. 2), which covers a 32,000 square foot area, has 40ft by 50ft bays which run to heights of about 26ft. It is divided into three general sections—a manufacturing area, a laboratory area used for material accountability, quality control, and research and development, and an office, canteen and locker room area for personnel and administrative use. The soil at the works site is a heavy clay underlain by rock, which will prevent the escape of fissionable material by seepage into the substrata, in case of an accident. The walls and partitions around the manufacturing area have been made unusually dust tight to keep radioactive material from escaping. The exterior wall consists of continuous 5ft high aluminium windows with fixed glazing, above and below which are metal sandwich panels. These panels consist of a 2in insulating core, an exterior facing of brown, asbestos-protected metal and an interior facing of aluminium-painted sheet steel. Aluminium paint was used extensively throughout the works because it can be removed easily if contaminated. The partitions are also made of metal, and all joints are caulked with a plastic, to obtain dust-tightness. The floor in the manufacturing area is a 6in concrete slab on compacted fill topped with 6in of blue stone. The slab is heavily reinforced with $\frac{1}{2}$in round bars 6in centre-to-centre, to prevent cracks where fissionable dust might accumulate. It has a smooth finish to facilitate easy cleaning.

The critical experiment facility was built on a fence-enclosed plot 180ft by 210ft. Making up this building are a concrete bay 35ft high, which will be the scene of actual testing activities, and a low wing of construction similar to that of the fabrication shop. The boiler-house covers a 40ft by 80ft area, and is equipped with an oil-fired Babcock and Wilcox "FM-48" boiler and auxiliary equipment with a steaming capacity of 22,000 lb per hour. Another boiler of the same model will be installed later. The building also contains a single-stage, 100 lb per square inch air compressor, with space reserved for a duplicate unit to be installed in the future.

Both the fuel element fabrication shop and the boiler-house have structural steel framework designed to handle wind loads of 35 lb per square foot of projected building surface. The personnel, purchasing and security functions

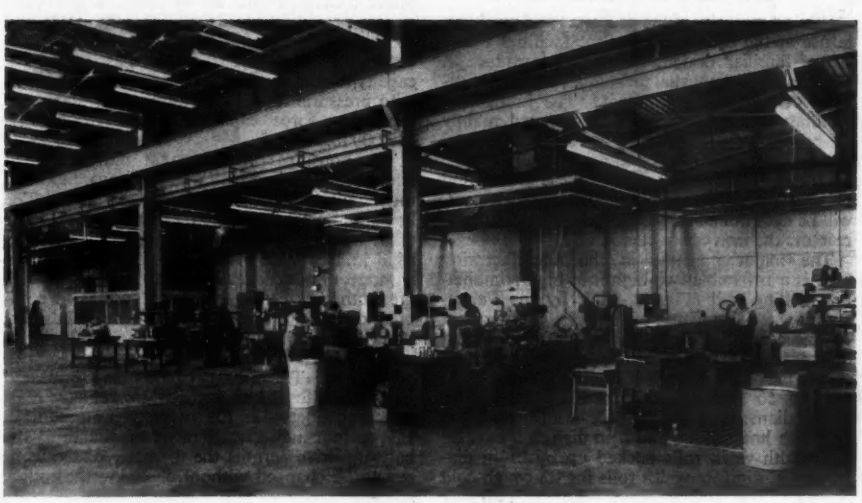


Fig. 2—Machine shop section of nuclear fuel element fabrication works

are quartered in a 30ft by 40ft brick gate house. Heated and cooled by a heat pump system, the building is the terminal and access control point of a linked wire fence enclosing the fabrication area.

Despite its proximity to the James River, the company experienced some difficulty in meeting the water demands of the works. Twelve widely separated wells were drilled at depths ranging from 150ft to 200ft, with inadequate results. A filtration plant with an ultimate capacity of 350 gallons per minute, using James River water, is now under construction to provide the pure water which will be required in the future. The filtration plant is a package unit using a Spaulding patent precipitator, gravity filtration and chlorination. Supplementary equipment includes a 150,000-gallon storage tank; a distribution system with a 6in fire main, hydrants and hose houses, and a 4in line to the critical experiment building.

Electric power for works operations is supplied by the Appalachian Electric Power Company. Initial power is being supplied from the end of an existing 33kV system. A new 110kV loop is being planned and should be available when the works demands reach 5000kVA. At present power is bought at 12kV and transformed to 480V in four load centres totalling 3250kVA capacity.

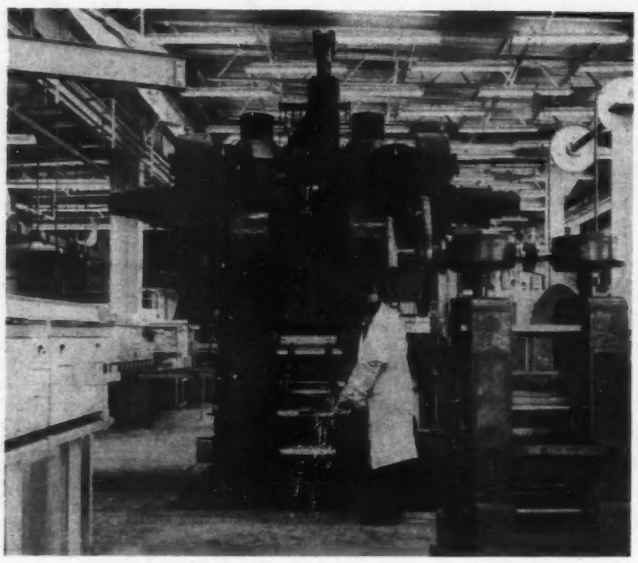


Fig. 3—Farrel-Birmingham 6½in and 21in by 22in two-high/four-high combination rolling mill

Fig. 4—Electric box furnace and Stanat 1½in and 5in by 8in two-high/four-high combination rolling mill

Fuel Element Fabrication Plant

While a majority of the processes and machines in use at the company's nuclear facilities works are of familiar design, fuel element production requires certain unusual techniques and modifications of standard equipment. The fabrication building and tools have been designed mainly to produce flat-plate fuel elements by metal casting, rolling, welding and machining. The thickness, width and length of these plates, and the arrangement of the plates to form an element, will be determined by the demands of the various reactors the firm contracts to build.

The major machine in the manufacturing area is a reversible two-high/four-high combination rolling mill (Fig. 3), built by the Farrel-Birmingham Company, of Ansonia, Connecticut. To accommodate a variety of fuel element designs in the future, it has been arranged to obtain maximum flexibility of operation. Driven by two 50 h.p. d.c. motors, the mill utilises 21½in diameter by 22in face width rolls for two-high hot rolling, and 6½in diameter by 22in face width work rolls backed up by 21½in diameter by 22in face width rolls for four-high cold rolling. The rolling speed can be infinitely varied from 0ft to 216ft per minute, and the rolling direction can be reversed instantly. The mill has Timken tapered roller bearings on the roll necks with pressurised lubrication. The maximum separating force capacity of the mill is 1,500,000 lb. Pratt and Whitney load cell blocks are used in development work to minimise the possibility of exceeding the maximum allowable separating force. The mill screwdown system consists of a dual arrangement with a declutching provision. The high-speed gear is driven by two 3 h.p. motors, and can be run at 4½in per minute. The low-speed screwdown gear is powered by two 10 h.p. motors, and operates at 0·109in per minute. In the roll drive arrangement, a double pinion stand permits driving either the back-up rolls or the work rolls when operating the unit as a four-high mill.

The second mill in the manufacturing area is a smaller reversible two-high/four-high combination rolling mill (Fig. 4), built by the Stanat Manufacturing Company, of Long Island City, New York. This machine, too, has been designed to offer great flexibility of operation and is proving particularly valuable in the finish rolling of fuel element and other reactor materials down to relatively thin gauges of sheet, held to extremely close thickness tolerances. Driven by a 15 h.p. a.c. motor, the mill utilises 5in diameter by 8in face width rolls for two-high hot rolling, and 1½in diameter by 8in face width work rolls backed up by 5in diameter by 8in face width rolls for four-high cold rolling. Speed control is obtained by a manual gear-shift system providing speeds of 30ft, 60ft, 110ft and 185ft per minute, and the rolling direction can be reversed instantly. The mill has "Orange" cage type needle roller bearings on the roll necks with pressurised oil lubrication. The maximum separating force capacity of the machine is 150,000 lb.

The housings of the Stanat mill are high-strength "Meehanite" iron castings mounted on a unit base of fabricated steel plate. The housing posts have been designed with large cross-sectional areas to obtain an extremely rigid mill capable of handling severe roll loads without undue deflection. A mechanical roll lift method is employed, using springs in combination with lift rods. The single handwheel screwdown is manually operated and is equipped with a clutch device for the correction of roll parallelism. The opening of the rolls is indicated in thousandths of an inch by micrometer dials directly connected to the screwdown mechanism. In the four-high arrangement of the mill, the back-up drive permits the diameter of the work roll to be changed without changing the rolling speeds.

It is of interest to note that the concept of a two-high/four-high combination rolling mill is to-day particularly popular in the nuclear materials processing field in the United States. Such machines generally enable the entire range of rolling operations—from the hot breakdown of uranium and plutonium ingots to the cold finishing of thin-gauge sheet—to be performed in only one or two mills, thus offering considerable space and investment economy. Such a machine may be considered primarily as a two-high mill designed so that the rolls can be raised sufficiently to insert between them a set of two small-diameter work rolls. Alternatively, it may be regarded as a four-high mill with driven back-up rolls designed to facilitate rapid change-over to a conventional two-high configuration by the withdrawal of the two work rolls. In the latter use, the original back-up rolls thus become the work rolls in the two-high arrangement. It is well known that the object of all forms of backed-up rolling mills is to obtain the largest practical reductions in the diameter of the work rolls. Extensive research into the cold rolling of strip has established that—for a given material, reduction and width—the roll load, rolling torque, rolling horsepower and lateral spread of the strip decrease with the diameter of the work rolls. Consequently, for a mill of given roll load capacity and horsepower greater reductions may be taken with work rolls of small diameter. The reduction in lateral spread with reduction in work roll diameter also has considerable practical advantage in rolling the harder nuclear materials since it reduces the tendency of the strip edges to tear or crack. The "stiffness" of the backed-up four-high mill and the ease with which its small work rolls can be crowned, have made it possible to produce extremely accurate strip with practically no gauge variation across its width. Finally, a smaller work roll permits thinner strip finishing gauges even in highly work-hardened materials, since the length of the flattened arc of contact between the work rolls and material—and, hence, the roll load and rolling torque—decreases with decrease in work roll diameter. In such an "all-purpose" mill there is much to be gained from driving the back-up rolls rather than the work rolls. Despite the original objection to this method on the ground that slipping would occur between the work rolls and the back-up rolls, extensive and successful service of four-high mills driven by back-up rolls in the American metal industry has proved the soundness of this design. The back-up drive eliminates one of the serious disadvantages of the conventional four-high mill driven by work rolls, namely, the limitation in torque that can be transmitted by the relatively small roll necks and spindles without exceeding their permissible torsional strength.

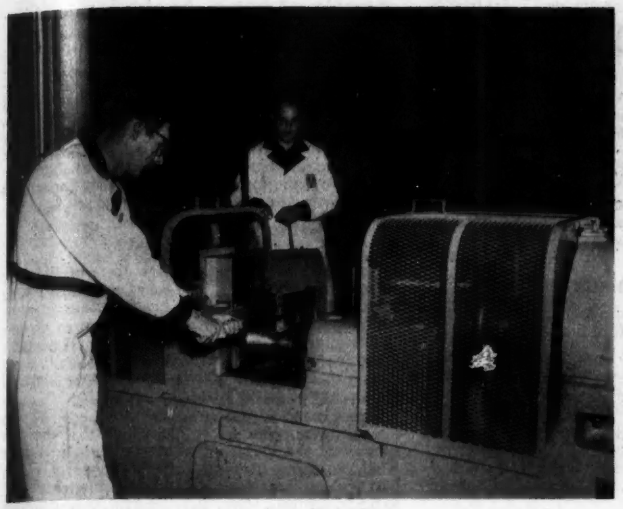


Fig. 5—Breaking down of arc-melted ingot on Chambersburg "Impacter" forging hammer

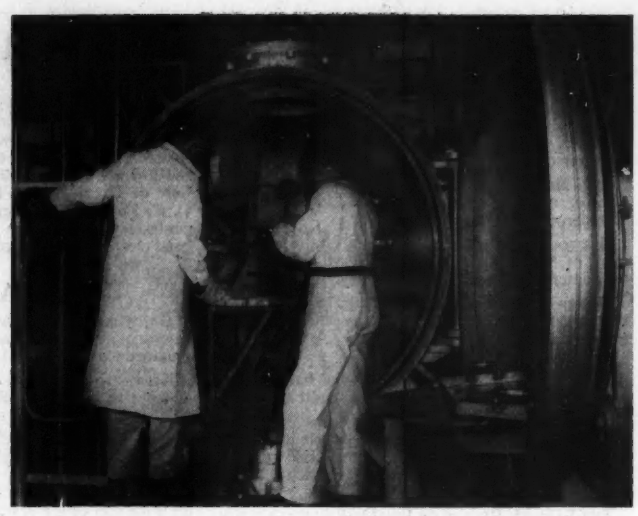


Fig. 6—National Research Corporation 100 lb capacity vacuum induction melting furnace

Another valuable property of the back-up drive is its ability to overcome the lateral bowing-out of the small work rolls when heavy reductions with high front tension are taken. Driving the back-up rolls causes a torque reaction on the work rolls which tends to bend them toward the entry side of the mill, i.e. in the opposite direction to the force exerted by the coiling reel. By balancing this torque reaction and the strip tensions, the tangential force on the work rolls can be eliminated altogether.

At the new installation, hot rolling, although possible on either mill, is being concentrated on the Farrel-Birmingham unit. The material is heated to rolling temperature in either a box furnace or a salt bath furnace. Although this mill can be equipped with specialised handling gear, material will generally be handled manually. Normally the nuclear material is hot rolled, using intermediate reheats, to the desired thickness, and is then cold rolled either on the Stanat mill or on the Farrel-Birmingham mill after a roll change.

Initially, forging operations are used to break down the 6in diameter arc-melted ingots to 1in thick slabs for subsequent hot rolling. The materials are heated in either the salt bath or the box furnace, and forged on an "Impacter" horizontal forging hammer (Fig. 5), built by the Chambersburg Engineering Company, of Chambersburg, Pennsylvania. The hammer has a capacity of 6000ft-lb per blow. It is air operated, but can also be steam-powered. Work is positioned between the dies by means of a guide roller, and all the energy of the blow is imparted directly to the work. Each blow is controlled by the operator through the movement of a valve. Should it become necessary, the "Impacter" may also be used with forming dies to facilitate small parts production.

Achieving economical welds which are uncontaminated, corrosion-resistant and non-porous is vital in fuel element fabrication. Most welding in the American nuclear industry to-day is performed in "dry boxes," evacuated and filled with inert gas to prevent the contamination of the material being welded. It is a time-consuming and costly process. Instead, the Babcock and Wilcox Company decided to use Heliarc welding employing a concentration of helium or argon gas in the welding zone to protect it from contamination by atmospheric gases. Welding heat is provided by an electric arc struck between a tungsten electrode and the workpiece. Since no flux or filler rod is required in this process the welds can be made on a variety of joints and metals. Either an a.c. or d.c. generator is used in welding, with a specially-designed water-cooled torch to cool the tungsten electrode. The shielding gas passes through the torch from gas cylinders by means of flexible tubing.

When dealing with material which has a high melting point and is readily contaminated by crucible components, it has now become common practice to melt by a process which utilises the material itself as an electrode source. Generally, the electrodes consist of compacted sponge zirconium and alloying materials. An arc is struck with an electrode in the bottom of a water-cooled copper mould, and the power input is adjusted to maintain a constant and stable arc as the ingot builds up and the electrode melts away. Melted in the atmosphere of an argon-helium mixture, the electrode forms a 4in diameter ingot. In turn, this ingot is used as the electrode for the re-melt to produce a 6in diameter ingot for further processing.

A vacuum arc furnace built by the National Research Corporation, of Cambridge, Massachusetts, is employed in the arc melting process at Lynchburg. The furnace has an electrode tower which houses the electrode on initial charging. During the re-melt operation the tower is removed. Guide rolls, electric contact rolls and the electrode drive mechanism are housed in a bell or centre section. A variable-speed drive, which is actuated by power fluctuations during the melting, controls the drive mechanism. During start-up and shut-down the operator can stabilise the arc by means of an override mechanism. Sealed by gaskets into the bottom of the bell section is a water-cooled copper mould. This arrangement permits the circulation of cooling water at high velocity to solidify the ingot quickly. The bottom of the mould is insulated from the sides to ensure that power flows from the electrode through the ingot into the bottom contact, thereby minimising the possibility of arcing to the mould side walls. The furnace has a vacuum system of 100 cubic feet per minute capacity, which is utilised for initial pump-down. Normally operations are carried out in a helium-argon atmosphere, at a controlled pressure to obtain minimum glow discharge. Three 1450A welding rectifiers, which can be controlled individually, make up the power supply.

For the production of certain fuel element alloys, induction melting and casting is employed. The process, which may be conducted in a vacuum, an inert atmosphere or in air, takes place in an 8ft by 6ft by 6ft furnace (Fig. 6), also made by the National Research Corporation. Although induction melting normally produces vigorous stirring due to the type of heat used, mechanical stirring has been found necessary to ensure good homogeneity when alloys of extreme density differences are processed in graphite crucibles. The furnace has a crucible capacity equivalent to 100 lb of steel. It is evacuated by a model "100-S" rotary gas ballast mechanical pump, and a model "B-6" booster pump. Power is supplied from a motor-generator set rated at 100kW. Water circulating through copper coils provides cooling for the stainless steel shell.

For vacuum melting, the various materials in the charge are placed in the crucible, inside the induction coil. All ports are closed and sealed with a vacuum grease. The vacuum pumps are then started up and the complete system is evacuated to the desired pressure of approximately 1 micron of mercury. The charge is melted by electric power applied in steps to the induction coil. Depending on the material being worked, a superheating period may follow. After pouring, the solidified ingot is not removed from its mould until atmospheric pressure has been restored. For melting in an inert gas atmosphere the charge is placed in the crucible and all furnace ports are sealed. One of the ports is specially designed for the insertion of the desired atmosphere. The furnace is then evacuated as desired, the vacuum isolated from the furnace shell, and the system purged to the desired pressure with the specified gas, such as argon or helium. The further steps are substantially the same as those used in vacuum melting. For melting in air the furnace door is closed but not sealed.

In fuel element fabrication the plates are machined to width and length on a milling machine. The end adaptors for the fuel "bundle" are machined to correct outside diameter, bore and square-end dimensions on a lathe and milling machine. The assembled element is machined to correct dimensions, after welding and end adaptor attachment, on a shaper-planer.

(*To be continued*)

Enrico Fermi Award to Dr. John von Neumann

DR. JOHN VON NEUMANN, of the U.S. Atomic Energy Commission, has become the first recipient of the Enrico Fermi award. The award, comprising a medal, a citation, and 50,000 dollars, was made in recognition of his outstanding contributions both to the theory and to the design and construction of fast computing machines.

The statement by the A.E.C. General Advisory Committee recommending Dr. von Neumann as the recipient said: "He was foremost amongst those who foresaw the importance and, indeed, the necessity for these fast computing machines in the development and design of the devices which are fundamental to the use and control of atomic energy. These machines have, in fact, been of the greatest utility especially in the design of nuclear weapons. They are now being increasingly employed in the design of power reactors. One of the most important of these machines, 'The Maniac,' was constructed under Dr. von Neumann's direct supervision, and his influence, his enthusiasm and ideas gave direction to the whole development. These remarks, which stress a single but extremely important facet of Dr. von Neumann's many contributions, should not make us forget the great but classified contributions which he made to the theory and design of both fission and thermonuclear weapons. However, it is our opinion that his contribution to the art and science of computation alone, as applied to the use and control of atomic energy, is more than ample justification for conferring the Fermi award of 1956 to Dr. John von Neumann."

Personal and Business

Appointments

MR. J. M. HALLETT has been appointed publicity manager of Ferranti, Ltd.

MR. HARRY WEST has been appointed managing director of A.E.I.-John Thompson Nuclear Energy Company, Ltd.

BRISTOL AIRCRAFT, Ltd., announces the appointment of Mr. Andrew McClements, M.I.Mech.E., as helicopter development manager.

POWER TOOLS (BIRMINGHAM), Ltd., has announced the appointment of Mr. L. Ford as senior technical representative in the London area.

THE NEW CONVEYOR COMPANY, Ltd., announces that Mr. E. Oldfield, who for some years has been the company's general sales manager, has been appointed sales director.

THE MINISTER OF FUEL AND POWER has appointed Mr. Ernest C. Willis, F.C.I.S., Comp.I.E.E., deputy chairman of the South Western Electricity Board from August 1st.

THE EASTERN REGION OF BRITISH RAILWAYS states that Mr. M. R. Bonavia has been appointed principal officer (modernisation), in the general manager's office, Liverpool Street.

ENGINEER CAPTAIN HERBERT MOY, C.B.E., M.I.Mech.E., who is a director of Spembly, Ltd., has recently been appointed technical director of Warsop Power Tools, Ltd.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., states that Mr. D. G. Smee has been appointed manager of the broadcasting division, in succession to Mr. H. A. Lewis, who is leaving the company.

METROPOLITAN-CAMMELL CARRIAGE AND WAGON COMPANY, Ltd., Saltley, Birmingham, 8, states that Mr. L. B. Alexander, London manager, and Mr. C. G. Wallace, secretary, have been appointed special directors.

THE MINISTER OF SUPPLY has appointed Air Vice-Marshal P. S. Blockey, C.V., C.B.E., B.A., to be Deputy Director-General of Aircraft Research and Development (R.A.F.) in succession to Air Vice-Marshal W. A. Opie, C.B., C.B.E.

THE UNITED STEEL COMPANIES, Ltd., state that Mr. G. H. F. Wingate, works manager (services) of Steel, Peech and Tozer, is to become director and general manager of Distington Engineering Company, Ltd., Workington, in succession to Mr. A. A. H. Douglas.

MR. CHARLES BAYLY, a specialist in rocket motor and guided missile engineering and a former senior executive at Woomera, who joined Sir W. G. Armstrong Whitworth Aircraft, Ltd., a year ago, has been appointed chief engineer of the company's Armaments Division.

MR. G. M. MENZIES, chairman and managing director of North British Steel Foundry, Ltd., has been elected chairman of the British Steel Founders' Association. Dr. C. J. Dadswell, a director of English Steel Corporation, Ltd., has been elected vice-chairman of the Association.

SIMON-CARVES, Ltd., announces that Mr. K. MacGregor, of the coke oven department; Mr. J. E. Chick, of the washery department; Mr. L. Brook, of the power plant department; Mr. A. E. Taylor, of the chemical plant department; and Mr. O. J. H. Simon, of the chemical plant department, have been appointed technical directors.

ENGLISH STEEL CORPORATION, Ltd., Sheffield, has announced the following appointments to the boards of its wholly-owned subsidiaries:—Mr. G. Craven, director of English Steel Forge and Engineering Corporation, Ltd., responsible for commercial matters; Mr. C. Muirhead and Mr. E. W. Greaves, directors of Davis and Lloyd (1955), Ltd.

STEEL, PEECH AND TOZER, a branch of the United Steel Companies, Ltd., announces that under staff changes, which will take effect on August 1, 1956, Mr. C. H. Hayter is to become works manager (services); Mr. N. H. Bacon, superintendent, Ickles departments; Mr. W. Ash, chief works metallurgist; and Mr. H. A. Longden, assistant chief works metallurgist.

THE MARCONI INTERNATIONAL MARINE COMMUNICATION COMPANY, Ltd., announces that with the creation of separate publicity and technical information departments, Mr. W. Maconachie has been appointed publicity manager, responsible for all publicity and advertising matters. Mr. L. A. Hooper, as manager of the technical information department, will deal with the production of instruction manuals and other technical literature.

THE LOCOMOTIVE AND ALLIED MANUFACTURERS' ASSOCIATION announces that Mr. Harold Wilmot, C.B.E. chairman and managing director of Beyer, Peacock and Co., Ltd., has been elected president of the Locomotive and Allied Manufacturers' Association of Great Britain for the ensuing year. Mr. C. C. H. Wade, manager of the traction sales and contracts of the English Electric Company, Ltd., has been elected chairman of the Association.

Business Announcements

HANWORTH ENGINEERING (AIRCRAFT), Ltd., has been acquired by the Camp Bird Industries Group and renamed Cold Forging, Ltd.

KELVIN AND HUGHES (MARINE), Ltd., has opened a depot at 4, Central Road, Docks, Southampton. Mr. M. M. Smith is the engineer in charge.

MR. W. A. COATES, M.I.E.E., F.Amer.I.E.E., retired from the board of Metropolitan-Vickers Electrical Company, Ltd., on July 4, 1956. He will continue as commercial consultant to the managing director until the end of the year.

MORTIMER ENGINEERING COMPANY has been appointed sole agents in the United Kingdom, Rhodesia, Denmark, Egypt, Sweden and Norway for the universal "Rindis" machine manufactured by Lorant and Co., Ltd., of Croydon.

A.E.I. LAMPS AND LIGHTING COMPANY, Ltd. a new company, has been formed by the British Thomson-Houston Company, Ltd., the Edison Swan Electric Company, Ltd., and the Metropolitan-Vickers Electrical Company, Ltd., to merge the lamp and lighting businesses of the three firms. The new company will supply the lamps and lighting equipment sold under the brand names of "Mazda," "Royal Ediswan," and "Metrovick" from strategically placed distribution points throughout Great Britain.

Contracts

BROOKE MARINE, Ltd., announces that a contract has been received from the British Transport Commission (Associated Humber Lines) for two twin-screw cargo passenger ships. The ships will have a length between perpendiculars of 285ft, a breadth moulded of 45ft by a moulded depth of 24ft 3in to upper deck, and carry a deadweight of 1100 tons. There will be accommodation for eighty passengers and a service speed of 15½ knots will be maintained by Ruston and Hornsby diesel engines of 3200 total b.h.p.

THE GENERAL ELECTRIC COMPANY, Ltd., has received contracts totalling £2,500,000 for generating plant to be installed in Australia, including two 60MW hydrogen-cooled turbo-alternator sets and condensing and feed heating plant, for the New South Wales Electricity Commission's Wallerawang power station. Steam conditions are 900 lb per square inch pressure and 900 deg. Fah. at the turbine stop valve, vacuum at m.c.r. (full load) 28·2in, and final feed temperatures 385 deg. Fah. The hydrogen cooling will operate at a pressure of 30 lb per square inch and the sets will generate at 11kV.

METROPOLITAN-VICKERS ELECTRICAL COMPANY Ltd., has been awarded a contract, value £1,750,000, for the supply of the five generators required for the first stage of the Zambesi hydro-electric scheme at Kariba Gorge, Rhodesia. The equipment will be manufactured at the company's Trafford Park works for commissioning in stages between 1960 and 1962. The five water turbine-driven a.c. generators are each rated at 100MW, 0·9 power factor, 18kV, three-phase, 50 c/s. They will be of the "umbrella" form, having the thrust bearing and guide bearing immediately below the rotor. The total weight of each generator will be about 720 tons and the overall diameter about 40ft. Metropolitan-Vickers voltage regulators of the magnetic amplifier type will be supplied with the generators.

C. A. PARSONS AND CO., Ltd., Newcastle upon Tyne, has received orders for 200MW turbo-generators for power stations in England and in Canada. One set has been ordered by the Central Electricity Authority; it is a single-line unit running at 3000 r.p.m. and operating with steam at a pressure of 2350 lb per square inch, a temperature of 1050 deg. Fah., and with reheating of the steam to 1000 deg. Fah. after expansion in the high-pressure cylinder. The set for Canada will be the first 200MW turbo-generator to be installed in that country, and the first 200MW set to be exported from England. It has been ordered by the Hydro Electric Power Commission of Ontario for the Richard L. Hearn Generating Station, Toronto. This machine is of the cross compound design, the h.p. line running at 3600 r.p.m. and the l.p. line at 1800 r.p.m., each line being coupled to a 100MW generator. The operating steam conditions are 1800 lb per square inch pressure, 1000 deg. Fah. temperature and with reheating of the steam to 1000 deg. Fah. after partial expansion. It will be the fifth machine to be installed by Parsons in this station, the four previous sets being for outputs of 100MW and installed in 1951–53.

Miscellanea

LIFT PLANNING RULE.—A new form of slide rule which provides a quick and easy method of finding information for lift planning has been introduced by Marryat and Scott, Ltd., Wellington Works, Hounslow, Middlesex. It covers the major requirements for designing passenger, hospital, service and goods lifts. Copies of the rules are available free to architects on application to the firm.

OIL CONSUMPTION.—Returns published by the Petroleum Information Bureau show that the consumption of petroleum products in the United Kingdom during the first quarter of the year increased by 12 per cent over the corresponding quarter in 1955, to 6,529,491 tons. Gas, diesel and fuel oils accounted for 2,607,178 tons, motor spirit for 1,405,666 tons, and aviation fuel for 415,751 tons, while kerosene and Derr fuels absorbed 464,938 and 420,773 tons respectively.

COMMERCE GRADUATES AND COST ACCOUNTANCY.—The Institute of Cost and Works Accountants and the University of Birmingham have agreed on an arrangement whereby graduates in commerce who have followed the University's three-year B. Com. degree course in general and industrial accounting shall be entitled to exemption from the whole of Part I of the Institute's intermediate examination. It is stated that an increasing number of graduates are taking up industrial accountancy as a career and the Institute therefore welcomes the agreement reached with the University of Birmingham.

LECTURES ON WELDING STRUCTURAL STEELWORK.—The new Institute of Welding has organised a course of lectures on the detail design of welded structural steelwork, which is to be held, in the evenings from October 3rd to December 5th next, at the Junior Institution of Engineers, Rochester Row, London, S.W.1. The prospectus of the course is divided as follows: (*a*) Fundamentals: the arc welding process; the welded joint; economics of welding design; (*b*) Structural Details: roof truss details; beam and girder details; column details; rigid frame details; tubular construction; and plate girders.

EDUCATION OF THE YOUNG WORKER.—The sixth Oxford conference on the education of the young worker was held last April, under the auspices of the Oxford University Department of Education. It considered in particular the needs of those young workers for whom at present there are no satisfactory schemes of training or further education. There were 130 people, representative of industry and education, who participated in the conference. The conclusions reached and the recommendations put forward at the conference have now been printed in a booklet (price 6d.), which can be obtained from the secretary of the University Department of Education, 15, Norham Gardens, Oxford.

"DIESELS IN INDUSTRY."—Two films, produced by Technical and Scientific Films, Ltd., on behalf of R. A. Lister and Co., Ltd., of Dursley, Gloucestershire, were shown in London last week. "Diesels in Industry" demonstrates some of the many applications of the modern medium-speed diesel engine in a variety of industries. The second film, "Railway Marshalling: The Modern Way," compares the diesel-electric shunting locomotive with its steam equivalent. Actual construction of the diesel-electric locomotive is shown, followed by details of normal working. The film concludes with a demonstration of some of the routine maintenance necessary to efficient working. Both films are on 16mm Kodachrome.

FERRYBRIDGE SIGNALBOX.—A new signalbox has recently been brought into use with additional siding facilities for the C.E.A. Ferrybridge "B" power station. The signalling installation is electro-mechanical and is controlled from a thirty-five lever frame of the standard N.E. Region pattern 5in centres, positioned so that the signalman operates the levers with his back to the running lines. There are five colour-light signals, two power-operated semaphore signals, seven mechanically operated semaphore signals, five disc signals, three sets of power-operated points, four sets of mechanically operated points and a remote-controlled six-lever ground frame. In addition, fourteen track circuits have been installed and thus facing point lock bars have been replaced by track circuit control; also standard block controls have been provided.

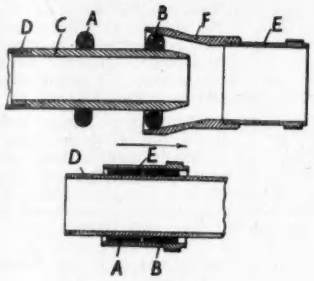
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

BEARINGS AND SUPPORTS

752,230. February 4, 1954.—Resilient Bearings and Production Methods, Société Anonyme André Citroen, 117/167, Quai de Javel, Paris (Seine), France.

The invention relates to resilient bearings which are constituted by two metallic bushes, between which there are disposed one or more rings of resilient material. The drawing shows a bearing before and after assembly. Two rings *A* and *B* are placed on the cylindrical plug *C*, which has at one end a portion of reduced diameter, over which there is fitted the inner bush *D*. The inner diameter of the rings is less than or at the most equal to the outer diameter of the bush *D*. The outer diameter of the rings is greater than the inner diameter of the outer bush *E*. The die member *F* is constituted internally by a truncated cone, the larger diameter of which is greater than the outer diameter of the intermediate rings *A* and *B* (prior to assembly), and the smaller diameter of which is equal to the inner diameter of the outer bush *E*. The inner form of the die member



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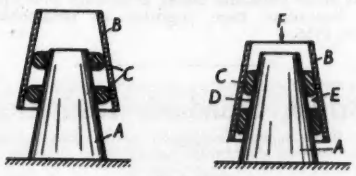
terminates in two cylindrical portions, the diameter of the first portion being equal to the inner diameter of the outer bush and the second portion being equal to the outer diameter of the same bush. This arrangement enables the die member to be fitted on the bush. The different parts being arranged as indicated in the upper view, the operation of fitting the bushes together is carried out by exerting a pressure in the axial direction indicated by the arrow on the inner bush *D*, and in consequence on the plug *C*. This penetrates into the die member and consequently into the outer bush, and has the effect of displacing the intermediate rings *A* and *B* by a rolling action over the plug and the inner bush on the one hand and against the die member and the outer bush on the other hand. The free space between the plug and the die member (or the outer bush respectively) being reduced in size, the intermediate rings are progressively deformed until they assume the flattened form illustrated in the lower view. It is also possible to manipulate the member *E* whilst the part *D* remains stationary. The originally circular form of the intermediate rings results in the fact that these have a resilient resistance to axial forces which is smaller than that obtained by previous methods. To remedy this defect the intermediate rings are fitted by the method described, but in a partly vulcanised condition. Once the assembly has been effected the rings are finally vulcanised so as to stabilise the rubber fibres in the deformed state. The resulting resilient resistance to axial forces is greater than that obtained by previously known methods.—*July* 4, 1956.

752,217. January 15, 1954.—Buffers, Hermann Joseph Neidhart, 4, Grand-Pré, Geneva, Switzerland.

The invention relates to a buffer for resiliently damping impacts or supporting loads in which rings of elastic material are arranged between opposite conical surfaces so as to be simultaneously compressed or simultaneously released when the buffer is loaded or unloaded. The buffer diagrammatically shown in the drawing comprises two elements *A* and *B*, which are movable in relation to one another, supported by two rubber rings *C* in such a manner that the two elements can axially displace themselves and can to a certain extent also tilt relative to one another. The element *A* is substantially frusto-conically shaped and may be solid or hollow, while the element *B* is constructed as a funnel. The rolling surfaces *D* and *E* facing one another of the elements *A* and *B* are conical and are disposed at an equal distance from one another. The rubber rings *C* are inserted loosely so that they can roll along the surfaces offered up. They are formed of rubber rods, which are bent into a ring and which accordingly are in equilibrium in every position when rolling as a consequence to a displacement of the two elements relative to one another. The rings can be inserted advantageously with preloading between the rolling surfaces. Instead of such rings, each of which is formed of one rod, rings which were made in moulds (vulcanised in the mould) or alternatively chains of loose or connected rollers of rubber or any other resilient material could be used. When loading the buffer by an axial



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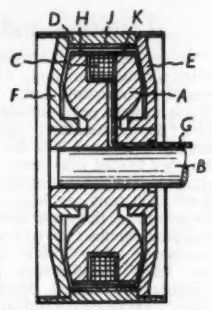
force *F* the rubber rings assume the shape shown in the right hand view. In order to prevent the rubber rings from slipping along the rolling surfaces these are roughened, fluted or grooved in the circumferential direction, &c. Even by the selection of suitable materials a surface finish can be attained which prevents any slipping, in that materials of high coefficient of friction are put into use. Moreover, the rolling surfaces may be roughened by treatment with a sand blasting gun, by knurling, &c. Different designs are also shown in the specification.—*July* 4, 1956.

ELECTRICAL ENGINEERING

739,588. August 6, 1954.—Magnetic Powder Clutches or Brakes, Elektro-Mechanik G.m.b.H., Wendenerhütte ü. Olpe, Westfalen, Germany (*Inventors: Walter Sussebach, Herbert Falderbaum and Johannes Schreiner.*)

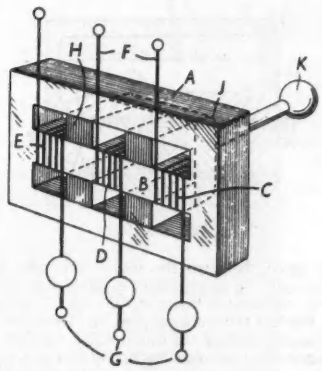
The invention relates to clutches or brakes in which the working connection between the two members of the clutch or the brake is effected by means of a magnetic powder subjected to the action of a magnetic field. As shown in the drawing, the clutch comprises an inner rotor *A* which is fast on a shaft *B* and carries a coil *C*. The rotor is surrounded by a belt pulley *D* supported by lateral discs *E* and *F*. The casing so formed is partly filled with magnetisable powder, not shown. The energising current is supplied to the coil *C* through conductors *G*. Between the outer face of the rotor *A* and the inner face of the belt pulley *D* the working gap *H* is formed, which is filled with the powder during operation. The faces *J* and *K* which confine the working gap, consist of a material which is harder than the material of which the powder is made. The faces may be surface-plated with a material which has a high resistivity to abrasion and to the effects of high temperature, and a non-magnetic material may be used advantageously for the plating of the faces which form the working gap.—*November*, 2 1955.



No. 739,588

749,000. November 6, 1952.—Variable Reactance Reactors, Ernest Alan Hinksman, 38, Freeth Street, Birmingham, 16.

The object of the invention is to provide a simplified or improved form of variable reactor. The drawing illustrates the application of the invention to a three-phase reactor, the magnetic core, *A*, being laminated. On the centre limb, *B*, of the core are mounted three windings, *C*, *D*, and *E*. Each winding is connected in series between one phase of the three-phase alternating current supply source, *F*, and one terminal of the three-phase motor, *G*, or other three-phase circuit to be controlled. The windings are fixed at spaced positions along the limb, *B*, leaving spaces between adjacent ends of the windings. Four sections *H* of laminated magnetic material are provided in the gaps between the centre limb and the two outer limbs of the magnetic core and these sections are designed for movement in a direction at right angles to the length of the limb and in the spaces between the adjacent ends of the windings. The sections *H* are fixed together in spaced parallel relationship by bridge pieces *J* to which is attached a handle *K* by means of which the sections *H* can be slid into and out of the spaces between the windings. In use, the reactor is connected in circuit as shown in the drawing and for starting up the motor *G*, the magnetic sections *H* are inserted into the spaces between the windings, to the position shown in the figure. In this position, the sections *H* form flux shunts in the magnetic circuit with a minimum magnetic coupling



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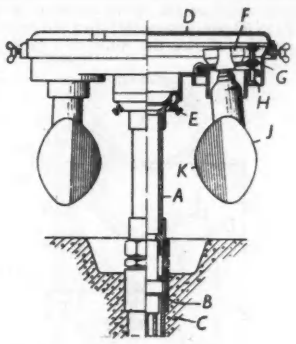
between the windings; consequently, the impedance of windings will be high. This high value of impedance can be used to control the starting current taken by the motor and/or the rate of acceleration of the motor. When the motor is up to speed or when it is no longer necessary to control the current or the rate of acceleration, the sections *H* can be withdrawn either partially or completely from the gaps in the magnetic core. This will have the effect of increasing the magnetic coupling between the windings and decreasing the impedance of the windings.—*May* 16, 1956.

739,757. January 22, 1954.—Ground Lights for Defining Airport Runways, Philips Electrical Industries, Ltd., Spencer House, South Place, Finsbury, London, E.C.2.

The invention relates to ground lights for use in defining areas on the runways of airports. From the drawing it will be seen that the ground lights comprise a vertical support *A* which is secured in the ground at *B* in a concrete block *C*. On top of the support is a



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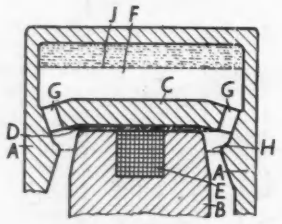
hollow cross bar *D* with a ball joint *E* to permit of varying the position of the cross bar within given limits. The cross bar encloses two lamp holders *F*. The holders are mounted on a base *G* the position of which is adapted to be adjusted by a screw *H*. The holders contain electric incandescent lamps *J* having each a bulb the rear face *K* of which is blown so as to be formed in the shape of a paraboloid and is internally mirrored. Modified designs of ground lights with a third lamp to throw light upwards are also shown in the specification.—*November* 2, 1955.

POWER TRANSMISSION

751,795. March 26, 1954.—Magnetic Powder Clutch, Elektro-Mechanik G.m.b.H., of Wendenerhütte über Olpe Westfalen, Germany.

The drawing illustrates a clutch designed according to the invention. As shown, the outer clutch member *A* surrounds the other clutch member *B*. The outer clutch member has two side walls and a cylindrical end wall and, at a certain distance from the latter, an inner transverse wall *C*. This transverse wall forms a shallow trough where it faces the inner member *B*, and these oppositely disposed faces form a cylindrical gap which is the working gap *D* of the clutch. The inner clutch member *B* accommodates an energising coil *E*. Between the transverse wall *C* and the cylindrical outer wall of the clutch member *A* an annular space *F* is formed, which serves as a re-

ceptacle for excess powder. The transverse wall *C* is provided with a number of substantially radially extending ports or channels *G* which are disposed near to the lateral walls of the outer clutch member *A* and connect the outer annular space *F* with the



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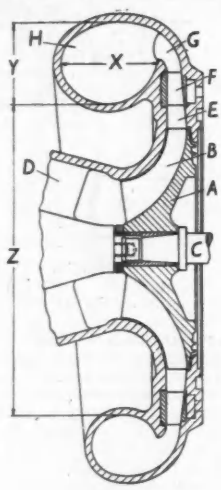
lateral spaces between the inner and outer clutch member, and the arrangement is made such that the ports or channels *G* open at the rim of the trough which borders the working gap *D*. The inner faces of the lateral walls of the outer clutch member *A* are so designed that on speeding up, when the powder is subjected to the action of centrifugal force, the powder is guided and directed towards the working gap *D* so that only after the working gap has been filled the excess powder is caused to pass through the connecting channels *G* into the outer receptacle. The dashed line *H* indicates the level which the powder assumes in the lower part of the clutch when the clutch is at rest, whilst the line *J* indicates the level of the excess powder in the receptacle *F* during operation of the clutch. The constructional example shown can be modified in various ways without departing from the scope of the invention.—*July* 4, 1956.

BLOWERS AND COMPRESSORS

751,906. July 1, 1954.—RADIAL FLOW COMPRESSORS, Maschinenfabrik Augsburg-Nurnberg A.G., Stadtbachstrasse 7 (13b), Augsburg 2, Germany.

The invention relates to the construction of the spiral casing used in radial-flow compressors, and relates more particularly to a spiral casing for compressors having a radial outflow of the operative medium from the rotor or subsequently connected guide apparatus. It has been found advantageous if the axial width of the spiral collector is approximately 20 to 60 per cent greater than the radial width. As the drawing shows, the rotor of a radial blower



No. 751,906

comprises a disc body proper *A* and rotor blades *B*. The rotor is rigidly connected to a rotor shaft *C*. Operative medium is drawn in substantially axially through a flow channel *D*, is deflected within the rotor channels in a radial direction and leaves the rotor channels in a compressed condition. The compressed medium is supplied to the exit diffuser vanes *F* after passing through an annular space *E* of continuously decreasing cross-section. The individual stream lines of the medium are straightened in the apparatus F, whereafter the flow is deflected from the radial outflow plane of the rotor within an annular channel *G*, the flow channel width of which is maintained, up to the entry into a spiral collector *H*, substantially the same as that at the exit from the exit guide apparatus *F*. The collector itself is constructed upon the constructional principles according to the invention. The axial width *X* of the cross-sections of the collector *H* is greater than the radial dimension *Y* thereof, and its minimum internal diameter *Z* is at least as great as the entry diameter of the blading of the exit diffuser vanes *F*. The operative medium flows outwardly into the spiral shown in the drawing along the right hand casing wall and then reverses inwardly after having travelled around a relatively large part of the periphery about the rotational axis. The flow pattern is therefore clearly determined. If a spiral casing is used in combination with a small radial dimension and with suitably constructed rotors and guide wheels, it is possible to obtain with a relatively small structural outlay efficiencies which have not heretofore been regarded as obtainable.—*July* 4, 1956.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

METHODS OF TESTING WATER USED IN INDUSTRY

No. 2690 : 1956. Price 17s. 6d. When the proposal was first made to draw up standard methods for the physical and chemical examination of waters used in steam generation, it was suggested that three groups of methods would be required. The first of these groups, already issued as B.S. 1427, describes tests which can be made even when ordinary laboratory facilities are not available. The present standard, B.S. 2690, while it includes some of the tests already given in B.S. 1427, consists mainly of tests which require laboratory facilities and call for chemical training on the part of the operator. The scope of the tests has also been widened, so that the methods given are more generally applicable.

The third group had been intended to serve research workers, but during the preparation of B.S. 2690 it became evident that the third group would be of little use. Many of the methods in this British Standard are directly applicable to research problems, and in those instances where special methods have to be devised it is considered that they would probably be of such limited application that their publication in the form of a British Standard would be unlikely to prove of general interest.

Launches and Trial Trips

VIVIEN LOUISE, oil tanker ; built by the Furness Shipbuilding Company, Ltd., for the British Oil Shipping Company, Ltd.; length overall 593ft 2in, length between perpendiculars 560ft, breadth moulded 80ft, depth moulded 42ft 3in, draught Lloyd's summer freeboard 32ft 4in, deadweight 24,850 tons, designed loaded trial speed 14¼ knots ; twenty-seven oil cargo compartments, one main cargo pump room, three 1000 tons per hour turbine-driven centrifugal cargo pumps, three 150 tons per hour vertical duplex stripping pumps ; cargo mains 13in bore; steam deck machinery : two 350kW turbine-driven generators, one 75kW diesel-driven generator ; one set of Metropolitan-Vickers double reduction geared turbines, 7300 normal s.h.p. at 100 propeller r.p.m. and 8200 maximum s.h.p. at 104 propeller r.p.m.; steam supplied by two Foster-Wheeler " D " pattern water-tube boilers at 450 lb per square inch and 750 deg. Fah. Trial, July 5th.

ATALANTI M. LIVANOS, closed shelter deck cargo ship ; built by the Burntisland Shipbuilding Company, Ltd., for Fomentador Compania Naviera S.A., Panama ; length between perpendiculars 435ft, breadth 59ft. 9¾in, depth moulded to upper deck 39ft 6in, deadweight 11,850 tons, draught 29ft 3in ; five cargo holds, one 30-ton and ten 10-ton derricks, electric winches ; three 150kW and one 35kW diesel-driven generators; Kincaid - B. and W., two-stroke single-acting diesel engine, seven cylinders 620mm diameter by 1870mm combined stroke, 5500 b.h.p. at 120 r.p.m. Launch, July 9th.

CARNATIC, refrigerated cargo ship ; built by Cammell Laird (Shipbuilders and Engineers), Ltd., for Shaw, Savill and Albion Company, Ltd.; length overall 512ft, breadth moulded 69ft, depth moulded to shelter deck 41ft 6in, load draught 30ft 3in, deadweight 11,200 tons, service speed 17 knots ; six cargo holds, one 70-ton, one 25-ton and 3-ton, 5-ton and 7-ton derricks; electric deck machinery: five 200kW diesel-driven generators, one 75kW auxiliary generator ; two Harland and Wolff single-acting, two-stroke, opposed-piston diesel engines, each of six cylinders, 750mm diameter by 1500mm stroke, 7150 h.p. at 118 r.p.m. Launch, July 11th.

IRISH POPLAR, cargo ship ; built by Cammell Laird (Shipbuilders and Engineers), Ltd., for Irish Shipping, Ltd.; length between perpendiculars 420ft, breadth moulded 62ft, depth moulded to upper deck 39ft, mean load draught 26ft 6in, deadweight 9150 tons ; four holds, one 30-ton, two 8-ton and ten 5-ton derricks; electric deck machinery : three 200kW diesel-driven generators ; one set of double-reduction geared turbines having two cylinders, steam supplied at 450 lb per square inch and 750 deg. Fah. by two Babcock and Wilcox sectional header water-tube boilers. Launch, July 12th.

OMMENKERK, closed shelter deck cargo ship ; built by the Netherlands Dock and Shipbuilding Company, for the Nereenigde Nederlandsche Scheepvaartmaatschappij ; length between perpendiculars 138·91m, breadth 19·13m, depth to upper deck 12·42m, deadweight 11,690 tons, speed 16 knots ; nine cargo holds, complement of 5-ton, 10-ton and 50-ton derricks and one 120-ton derrick ; three 200kW diesel-driven generators ; one Stork supercharged single-acting two-stroke, diesel engine, eight cylinders 750mm diameter by 1500mm stroke, 8100 h.p. at 115 r.p.m. Launch, July 14th.

SAN FELIPE, oil tanker ; built by Smith's Dock Company, Ltd., for the Eagle Tanker Company, Ltd.; length overall 557ft, length between perpendiculars 530ft, breadth moulded 69ft 3in, depth moulded 39ft, deadweight 18,217 tons on 29ft 10in draught, service speed 14½ knots ; thirty-three oil cargo tanks, one main cargo pump room, four 400 tons per hour turbine-driven cargo pumps, two stripping pumps ; two 550kW turbo-alternators, one 200kW diesel-driven alternator ; one set of Hawthorn Leslie two-casing, double-reduction geared turbines, taking steam at 500 lb per square inch and 800 deg. Fah. from two Foster Wheeler marine boilers. Trial, July.

H.M.S. KEPPEL, Blackwood class frigate ; built by Yarrow and Co., Ltd., for the Admiralty ; length extreme 310ft, length between perpendiculars 300ft, breadth extreme 33ft; complement seven officers and 104 men; three 40mm Bofors guns and two three-barrelled anti-submarine mortars ; one set of geared turbines. Provisional acceptance, July 6th.

H.M.S. WHITBY, Whitby class frigate ; built and engined by Cammell Laird (Shipbuilders and Engineers), Ltd., for the Admiralty ; length extreme 370ft, length between perpendiculars 360ft, breadth extreme 41ft; complement nine officers and 180 men; one twin 4·5in gun mounting, one twin-barrelled 40mm anti-aircraft gun, two three-barrelled anti-submarine mortars, two twin and eight single torpedo tubes ; two sets of geared turbines. Provisional acceptance, July 19th.

Catalogues and Brochures

DOUGLAS KANE ASSOCIATES, 5, New Quebec Street, London, W.1.—Leaflet describing a universal binding tool, the " Unibind " wire twister.

J. STEAD AND CO., Ltd., Manor Works, Cricket Inn Road, Sheffield, 2.—Catalogue and price list giving details of " Steadfast " high-speed and tungsten hacksaw blades.

HIGH DUTY ALLOYS, Ltd., Slough, Bucks.—Brochure entitled " Hiduminium Sheet and Plate," giving technical data to assist users in the selection of the most suitable alloy for their particular application.

JAMES ARCHDALE AND CO., Ltd., Blackpole Works, Worcester.—Abridged machine tool catalogue illustrating a cross-section of the standard and special-purpose machine tools manufactured by this company.

B. AND S. MASSEY, Ltd., Openshaw, Manchester, 11.—Leaflet No. 5670H, giving details of mechanical forging presses, which can be used for three distinct purposes—die forging, extrusion and coining. The control system, providing for either single or continuous stroking, is fully described and illustrated.

RESISTANCE WELDING MACHINE SECTION, BRITISH ELECTRICAL AND ALLIED MANUFACTURERS' ASSOCIATION, 36, Kingsway, London, W.C.2.—Illustrated booklet for overseas distribution, demonstrating ways in which resistance welding can be applied to old and new methods of manufacture. All of the illustrations in this booklet are captioned in English, French and Spanish.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

INSTITUTION OF ELECTRICAL ENGINEERS

Sat., July 28th.—LONDON GRADUATE AND STUDENT SECTION : Summer Outing, 1956. Visit to the College of Aeronautics, Cranfield, combined with a visit to Woburn Abbey, 8.30 a.m. (Savoy Place, W.C.2).

INSTITUTION OF NAVAL ARCHITECTS

Thurs., Oct. 11th.—Weir Lecture Hall, 10, Upper Belgrave Street, London, S.W.1, " Scale Effect Experiments on Victory Ships and Models," Part II, " Analysis of Wake Measurements on a Model Family and the Model Boat," D. C. Endert, Jr., J. D. van Manen, 4.45 p.m.

ROYAL METEOROLOGICAL SOCIETY

To-day and Sat., July 27th and 28th.—Pantycelyn Hall of Residence of the University College of Wales, Aberystwyth, two-day meeting in honour of Sir David Brunt.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

Fri., Oct. 19th.—39, Elmbank Crescent, Glasgow, Symposium on the application of Low-Alloy Steels for Welded Pressure Vessels, 10 a.m.